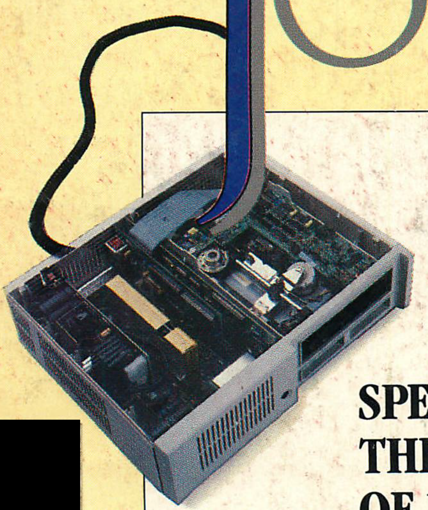
MAY 1984 VOL. 1, NO. 8 $3.95

FOR IBM PERSONAL COMPUTER USERS

TECH JOURNAL



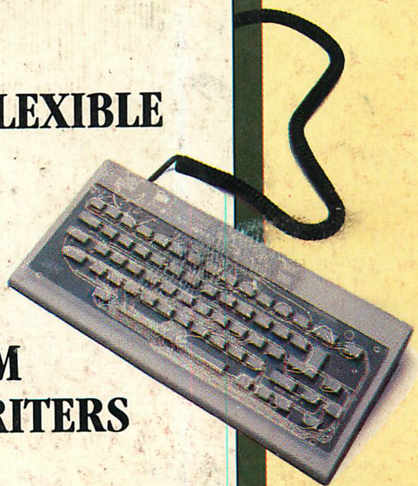
INSIDE *jr*

Compatible but strikingly different:
An expert looks at the anatomy of PCjr

SPECIAL SECTION
THE ART AND SCIENCE OF DEBUGGING

A new generation of debugging tools reviewed:
PC Probe and Program Execution Analyzer
Codesmith-86 and Trace86—assembly language debugging tools
A patch to DEBUG.COM—overcoming one small glitch
Program to single-step through a BASIC program

X-NET: AN INEXPENSIVE AND FLEXIBLE LOCAL AREA NETWORK



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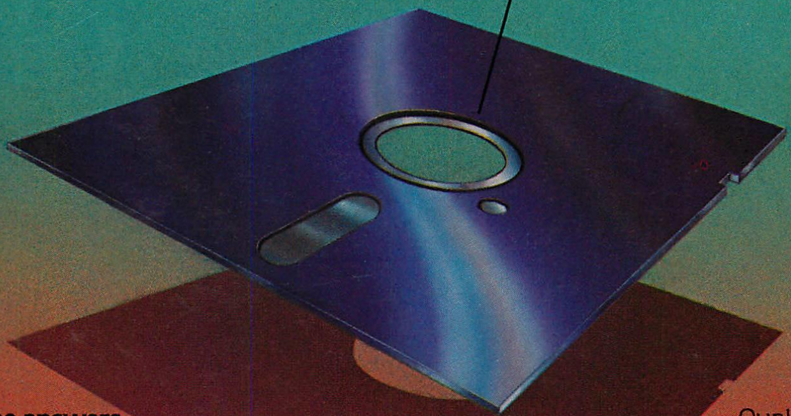

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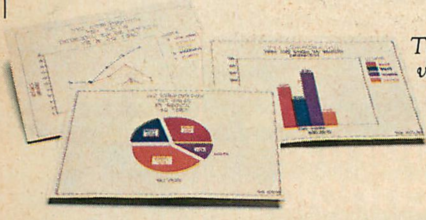

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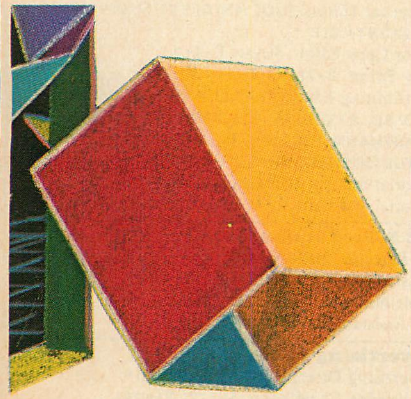

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May 1984

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Debugging

The art and science of making it work

WILL FASTIE

In my previous life (before *PC Tech Journal*, that is), I was a software developer. I was fortunate enough to be surrounded by an extraordinarily gifted and talented group of software experts, from whom I learned so much. Many in this group prided themselves on their clear, rational designs and their almost uncanny ability to write perfect code, programs that ran the first time. They often did that, much to the chagrin of us lesser mortals.

Every once in a while, these giants would falter, and some insidious bug would find its way into their code. Sometimes the originator of the bug would find and correct it, but sometimes the bug would elude even the most tenacious attempts to find and eradicate it. Then, a special breed of programmer would be called upon: a debugger.

I remember sitting in a computer room in Florida ten years ago. I was exhausted. I was in trouble. An important piece of my code worked fine, except that some of the terminals under its control would not respond. Worse, two versions of the system running an identical copy of my problem behaved differently: only one exhibited the bug. All this under the nose of my boss, who I was sure would can me any minute. Then he spoke up.

"It's a broken wire on the controller between the third and fourth bits of the address shift register." Uh huh. Sure it was.

It sure was. I was never so impressed in my life.

Now, I can say (with or without modesty as required) that I have solved a few in my day. I have also spent quite a bit of time producing tools to help me in the process. Without those tools, I think I might never have been a hero.

There can be little doubt that debugging is a scientific process. After all, computer systems are deterministic (that is, when they are working properly) and can therefore be described mathematically. Thus, it can be guaranteed that bugs will be killed if the programmer follows a strict, logical process. Right?

HA! I and thousands of other software developers wish it were that simple. The problem is easy to state: although debugging is strictly a mathematical problem, there are too many data points to consider (many of which are unknowns anyway) to successfully determine the describing function. That's a mouthful, isn't it? Think of it this way. If you knew the rules under which the system was operating, you could properly assess a particular behavior. Sometimes, however, you can build a system and not be completely aware of the rules.

Most software developers have been through this before. Sometimes we see a bug and say "Oh, I know what happened there. I forgot to put a semicolon on my PRINT statement in line 11457!" Sometimes we see a bug and say "No way. Period." Of course, we're quite wrong since the bug is there staring us in the face. Perhaps we don't want to admit our own error, especially when we don't happen to know just what it is yet.

And so sometimes it is wiser to consider debugging an art, something requiring practice, experience, intuition, insight, and creativity. On that long night in Florida, I doubt my boss reached his conclusion through a rigid thought process. Instead, I am sure he let his mind wander until his intuition started narrowing the problem domain, with the result being a flash of insight. *Then* he applied some logic: instead of just voicing a suspicion to be explored, he reasoned the precise bug.

By the way, that bug was esoteric. My code had not changed from version to version, but the system had grown one 16-bit word in size, moving an input buffer one word higher in memory. It was a short buffer, but the movement caused it to cross a 16-word boundary. The address register on the controller board could accept the proper buffer address but, being broken, couldn't increment across 16-word boundaries during the DMA process, wrapping instead. So, in one version my code worked and in the other it did not.

That leap of insight on the part of my boss pales in comparison to the one made by another associate of mine, John Dalesio. He simply *realized* that a tool *could* be built, designed its function, and then went

DIRECTIONS

about having some really bright engineers figure out how to do it. How much time their creation saved us over the next eight or so years is beyond counting.

We were using Intel's first chip, the 4004 (our company, General Instrument, was among the first of Intel's OEM customers). Of course, in those days support for the hardware was nonexistent. There was neither assembler (it was written in-house) nor debugger (the processor had no HALT instruction, much less a breakpoint trap). John and company debugged their programs using engineers, oscilloscopes, and sweat; strangely enough, the 4004 may have been the first speech recognition device, as it often seemed to respond to a barrage of four-letter words voiced at appropriately high decibel levels.

When John finished, he had built a device consisting of a black box, a $50,000 Data General NOVA computer, a large NOVA program, and a multitude of sockets and wires. As far as I know, it was the first in-circuit emulator, predating Intel's ICE for the 8008 by a year.

Today, most processors are designed and built with facilities to enable the construction of powerful software debugging tools. In particular, the PC's 8088 includes the capability to interrupt program execution if a particular location is reached and the capability to execute only one instruction at a time. These simple features can become powerful debugging tools, such as Codesmith-86 and Trace86, reviewed in this issue.

Had John had even a quarter of the features offered by these tools, his in-circuit emulator (we called it the ROMulator) might never have been built. But we were lucky in a way, because the ROMulator had absolute control over the processor, something a software debugger cannot have. This gave John and his team the ability to detect hardware as well as software problems. Such features are now part of every such ICE with which I am familiar.

The issue you now hold also has reviews of two hardware products, PC Probe (an in-circuit emulator) and the Program Execution Analyzer (PXA, a bus monitor).

I have thought about that night in Florida in the context of these tools. What if I had had a debugger like Codesmith or Trace86? Would I have found the bug? No, but they sure would have helped narrow the field more than the limited debugger I had (because of space limitations, it was less than 256 words long). How about PC Probe or PXA? Yup. They would have allowed us to spot that particular problem right off the bat.

I find myself amazed at the products we have described for you here. Even the software tools, lacking as they do the absolute control of their hardware counterparts, are sophisticated, intelligent assistants to the software developer.

Perhaps with tools such as these we software developers can apply more of that artistic talent to the construction of better and better applications, and less to figuring out what went wrong.

This is a special and unusual issue of *PC Tech Journal*. In addition to the many fine articles on the topic of debugging, we are pleased to bring you our in-depth analysis of PC*jr*, written by Tom Hoffmann.

There is an important reason for mentioning this here. By now, PC*jr* is old news. Our article is not timely. As with all our articles, however, you have the assurance of knowing that the product under review has been carefully scrutinized. The entire editorial staff has made some contribution to the review. Our machine has been used for six weeks, and Tom has had a second system for almost a month.

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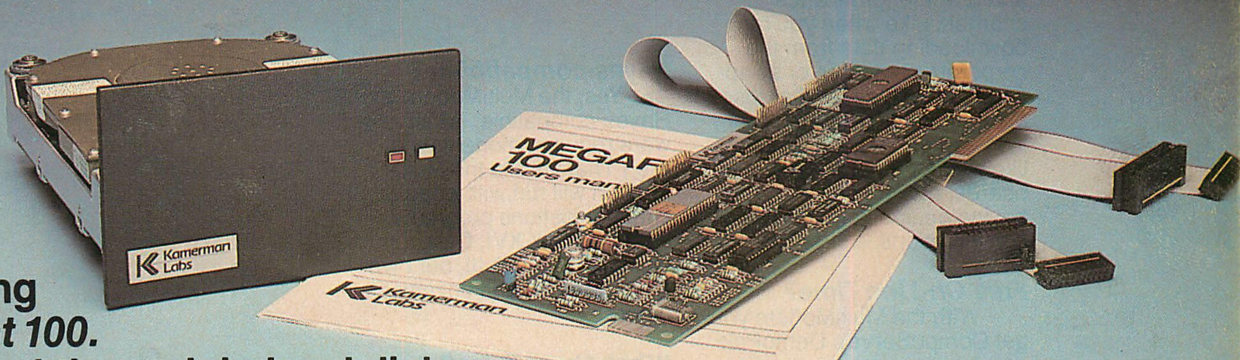

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Intelligence? Extra Features?

Of course, the MultiModem automatically dials, answers, and disconnects. But it does a few extra things too, things the Hayes Smartmodem 1200™ doesn't. Like recognize dial tones and busy signals, so the MultiModem will automatically redial, or automatically try a different number. And it remembers phone numbers too, up to six of them, in its battery-backed memory.

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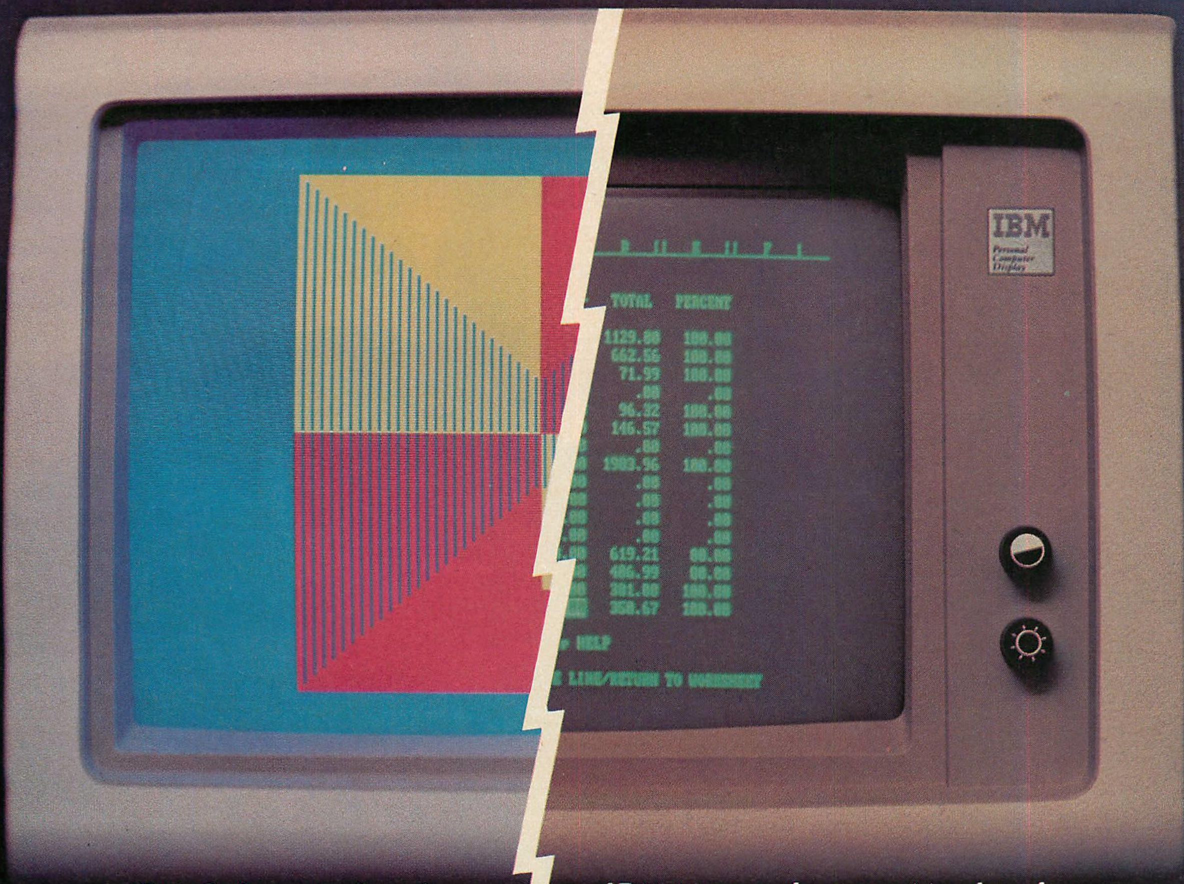

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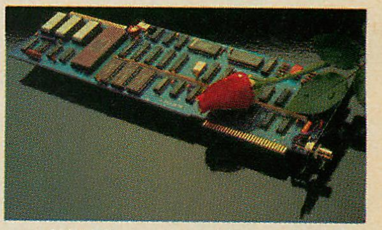

IRMA is a printed circuit board that slips into any available IBM PC/PC XT slot and attaches via coaxial cable to a 3270 controller. She's as easy to work with as the PC itself and provides standard text file transfer software

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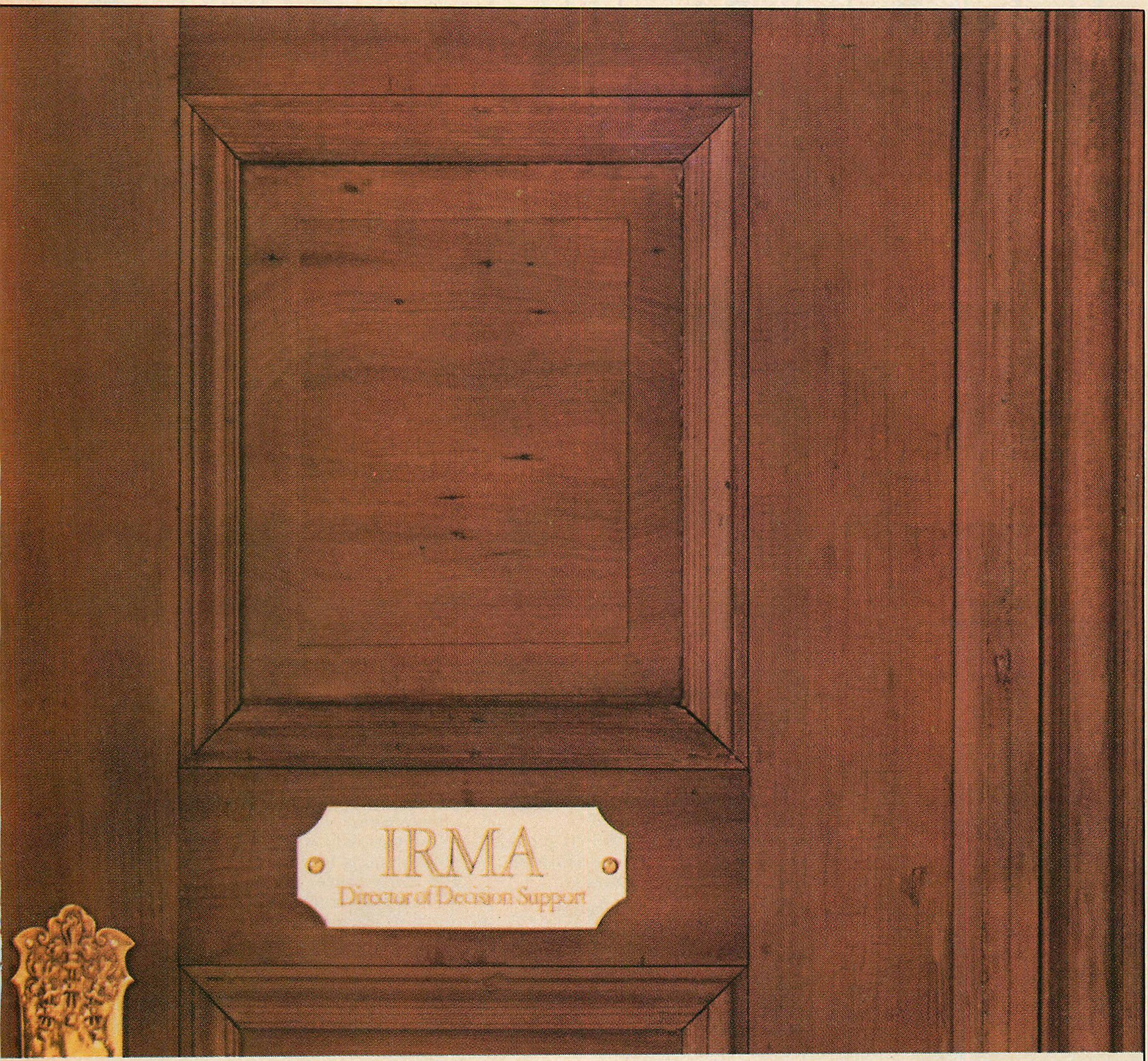

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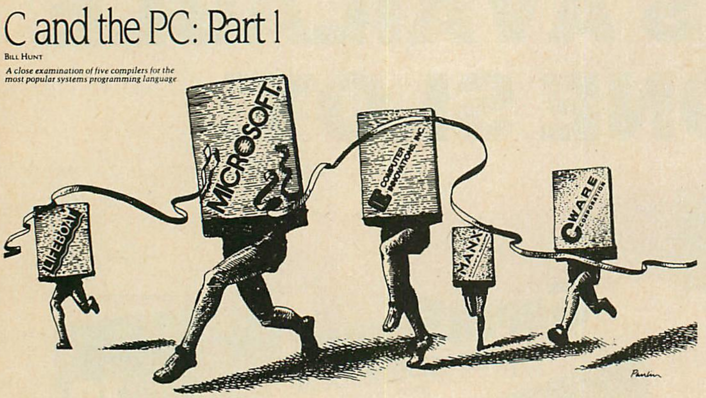

Come Back, Bill Hunt

I have just finished reading Bill Hunt's article on C compilers. Mr. Hunt seems to have an exceptional talent for writing a complete review that deals with the subject as a whole. Please have him do some more articles.

John J. Couture
San Diego, CA

We, too, are anxious to have more of Bill Hunt's reviews in TECH JOURNAL, and as soon as he polishes off a book manuscript that is under contract, we'll welcome him back to the fold.

—WF

Prompting Kvam

Bruce Kvam (Letters, February 1984) complains that DOS didn't provide a "Print Working Directory" command. Page 6-52 of my DOS manual states, "If you enter CHDIR or DC with no parameters or only a d: parameter, the current directory path of the specified or default drive is displayed." Bruce doesn't need to write his program, just a one-line BAT file.

Incidentally, I much prefer to provide this information in the prompt I use

PROMPT $E[S$E[H$E[31;47M$D $T PE[UQQ$E[37;44M

in conjunction with a CONFIG.SYS file containing "DEVICE-ANSI.SYS". This gives me a prompt (on a color monitor) that contains the date, time, and the current directory on the first line of the screen, in red letters on a white background, and leaves the rest of the screen blue with white letters. A short arrow "==>" appears on the current input as a prompt.

Harvey Horowitz
Pittsburgh, PA

Regarding Bruce Kvam's letter, it seems kind of ridiculous to me to write a program that does exactly the same thing as a system command! The cd command with no arguments is exactly equivalent to the Unix "PWD" command. For example, A>cd prints your working directory. Also, unlike Mr. Kvam's program, it will adapt the slashes to whichever directory delimiter you're currently using.

J. Eric Roskos
Nashville, TN

A Clearer View

In "Two Views of the LANscape," by Susan Glinert-Cole (January, 1984) you state on page 59 that "Sharenet must use an IBM fixed disk. Because the IBM controller is proprietary, other hard disks claiming IBM DOS 2.0 compatibility to do not work with Sharenet."

There is at least one other hard disk claiming IBM DOS 2.0 compatibility that does work with Sharenet: hard disk systems produced by Mountain Computer Inc., of Scotts Valley, California.

Mountain has achieved full plug compatibility by "totally" emulating the XT's hard disk controllers commands. No software patching or drivers are needed to set up the Mountain Hard Disk. As a demonstration of compatibility the Hard Disk controller of the IBM XT may be removed and replaced with Mountain's and the only difference is academic—such as increased error correction with Mountain's.

Novell has customers running Sharenet on the Mountain Hard Disk. Because of the complete compatibility, any software written to run on the XT's hard disk will most definitely run on the Mountain Hard Disk System.

David A. Doane
Product Marketing Manager
Mountain Computer Inc.

Paradise, $595

Thank you for including Paradise Systems in your article "Four Multi-Function Display Adapters" (January, 1984). It was a very interesting and helpful article.

I should point out that the product sells for $595 and will support Lotus 1-2-3 with either one or two monitors. Also, the switch that controls the logical location of the printer port is active all of the time and not just in monochrome mode.

It is exciting that you are now a monthly magazine. Congratulations.

Sandra J. Taylor
Public Relations Manager
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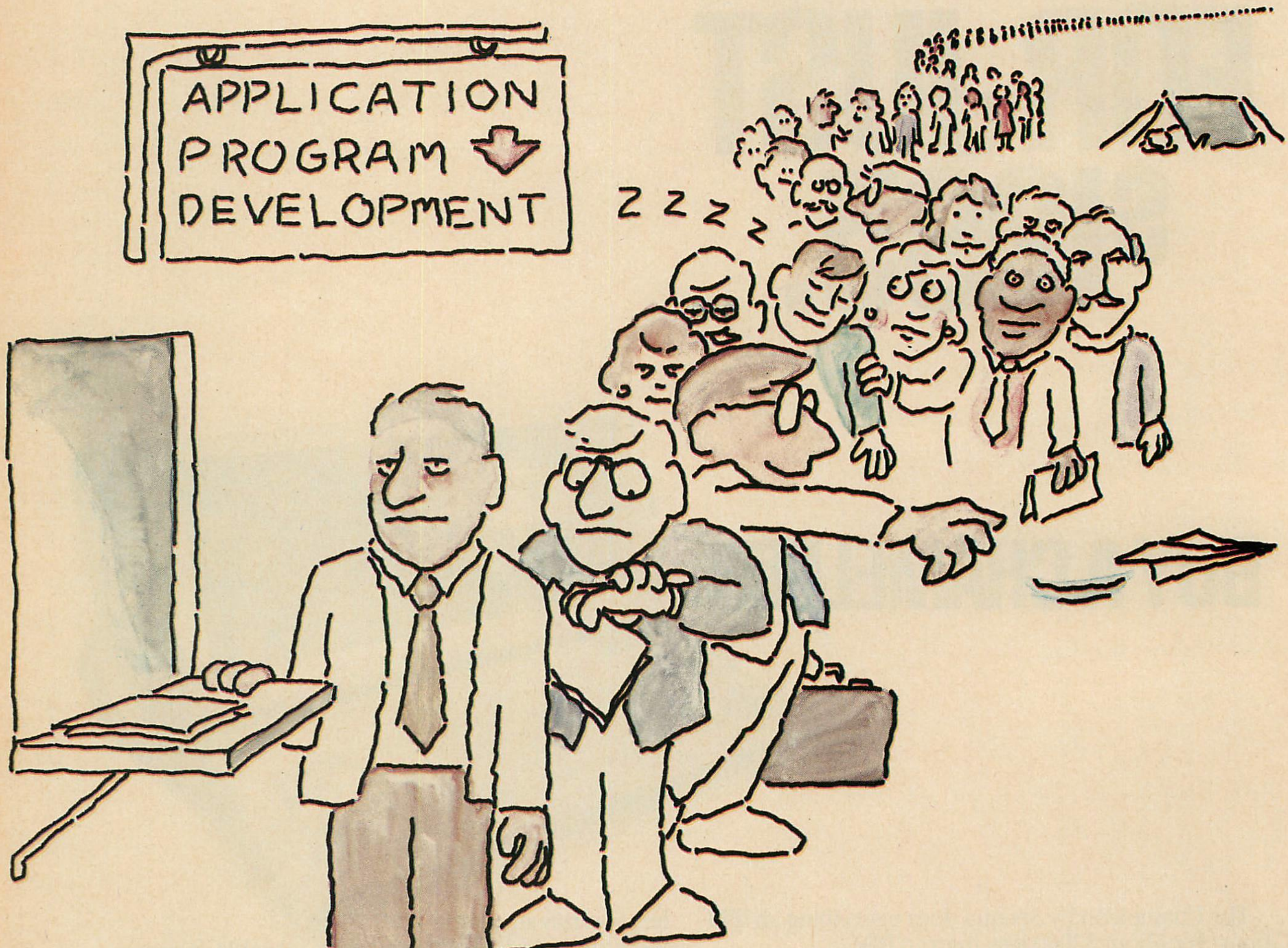

mes and cuts application software backlog.

A recent survey found that an average mainframe user would have to wait 3½ years for development work to begin on an application requested today.

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In the same study, managers felt on-line programming offered the greatest potential for reducing the backlog.

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If on-line programming offers the greatest potential for cutting application program development backlog, what's the problem?

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Productivity is substantially increased with m3278/SPF.

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Because the programmers' workstation is not down while programs are compiling or downloading.

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You may be able to eliminate application backlog without adding programmers. But, it is comforting to know programmers can be added without the expense of another host.

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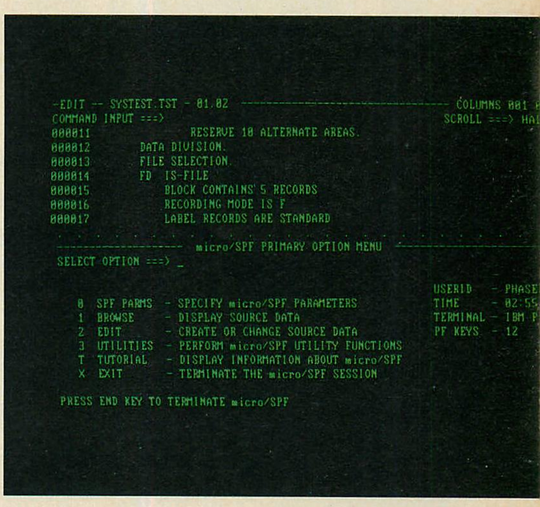

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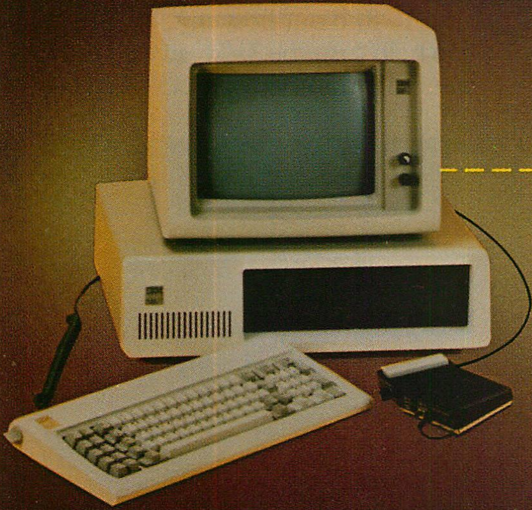
All versions of ELAN include an Ethernet interface and equipment to convert voice into data and back again. This enables one to give and receive spoken messages from any location. The SECRETARY is the basic system with these features.

SECRETARY $1695[1]
- Ethernet Link
- Ethernet Companion
- ELAN Software



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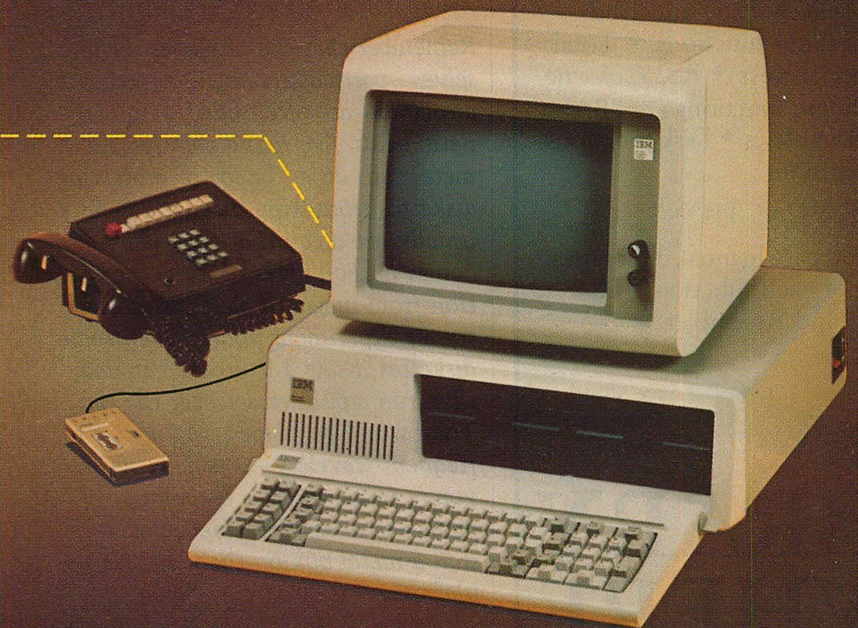
The MANAGER system adds a modem which can turn the PC into a telephone if a separate handset is added. The modem enables the MANAGER to receive unattended voice and data from any telephone in the U.S. or Canada. The MANAGER can accept commands by decoding the tones in the telephone keypad.

The EXECUTIVE is the most complete implementation of ELAN, adding computer recognition of spoken commands. An executive might phone the PC to leave or retrieve messages or request specific information. The PC, in a spoken voice, can request the user's access code or offer a list of options the user can select. The EXECUTIVE can then key in answers or commands with the phone's tone dialing buttons, or may simply speak his response to the computer.



MANAGER $1995[1]
- Ethernet Link
- Ethernet Companion
- Modem (300 Baud)[2]
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ZAPPED

I am currently part of a team working on a large application project to run on the PC. We have had to travel a great deal by air, and as a consequence our diskettes have been sporadically zapped. I believe that the magnetic fields of the X-ray equipment power supplies are the culprits. Although we remove the disks from our carry-on luggage just before entering the X-ray machines, we still sustain occasional damage, probably because the magnetic fields extend a significant distance around the X-ray equipment.

At this point my tactics are as follows: 1. I put a box of disks in a lead-foil film pouch (although I am doubtful that this really offers protection against magnetic fields).
2. Most importantly, I carry back-up sets of disks. This has allowed me to recover on all occasions.

One of our team members is convinced that some brands of disks are more susceptible to this kind of damage than other brands. Also, now that COMPAQ and others have portable hard disk systems,I wonder how the hard disk will react to airport X-ray systems. I would appreciate any additional information on this subject.

Steven A. Green
2393 Traymore Road
University Heights, OH 44118

The wonderful thing about working for a Ziff-Davis magazine is that the company represents expertise on such a wide range of subjects. We had only to call Dick Aarons, editor of another Ziff-Davis publication, Business and Commercial Aviation, *for some suggestions to Steven Green's dilemma. His advice follows. We welcome additional advice from readers.*

Remember that the airplanes themselves—particularly small corporate airplanes—are often filled with magnetic fields. I've found that ferrous metal cans do a fine job of protecting diskettes from stray magnetic fields. I usually use a can that fruitcake comes in. Foil gives really no protection from magnetic fields. You can try an experiment yourself: put some diskettes inside a fruitcake can and then run a bulk eraser over the can. They won't be zapped. My advice to frequent travelers—especially if you're traveling on a corporate plane—is to ask the chief pilot to install a metal box on the plane for regular use.

Dick Aarons
Editor,
Business and Commercial Aviation
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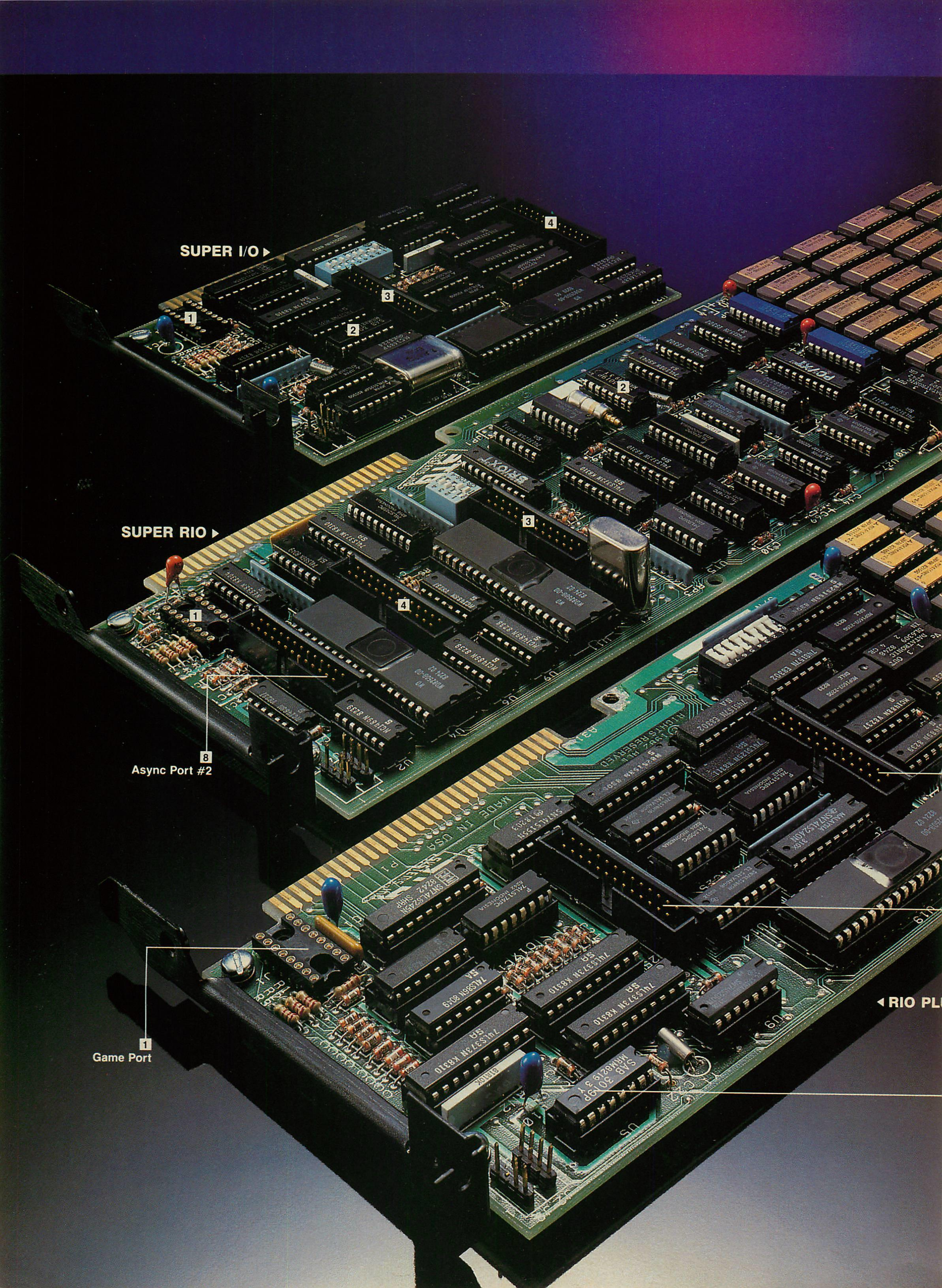
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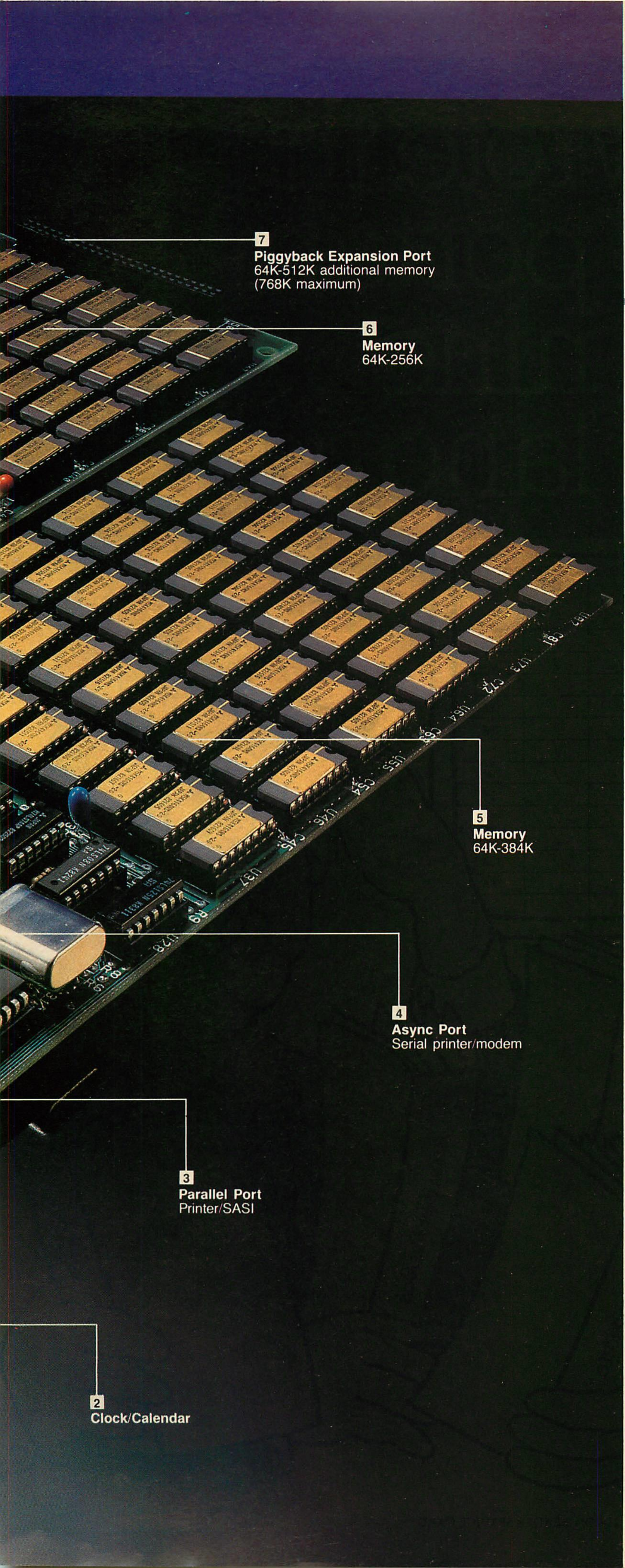

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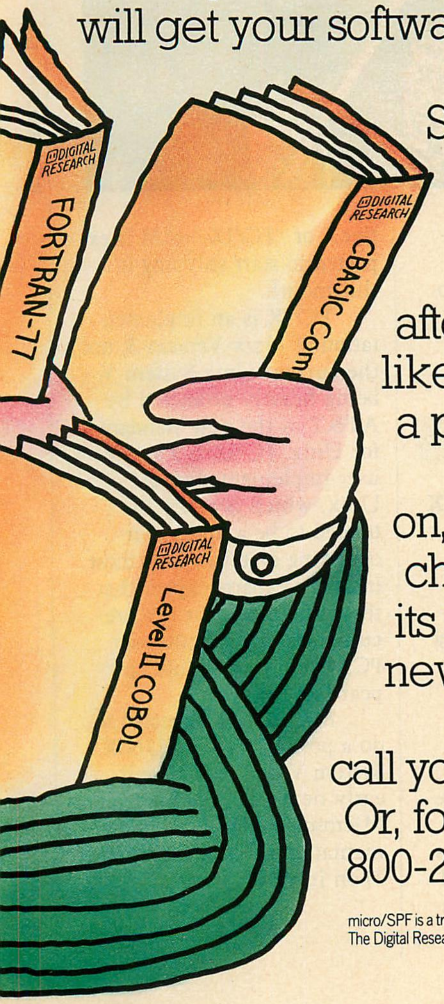

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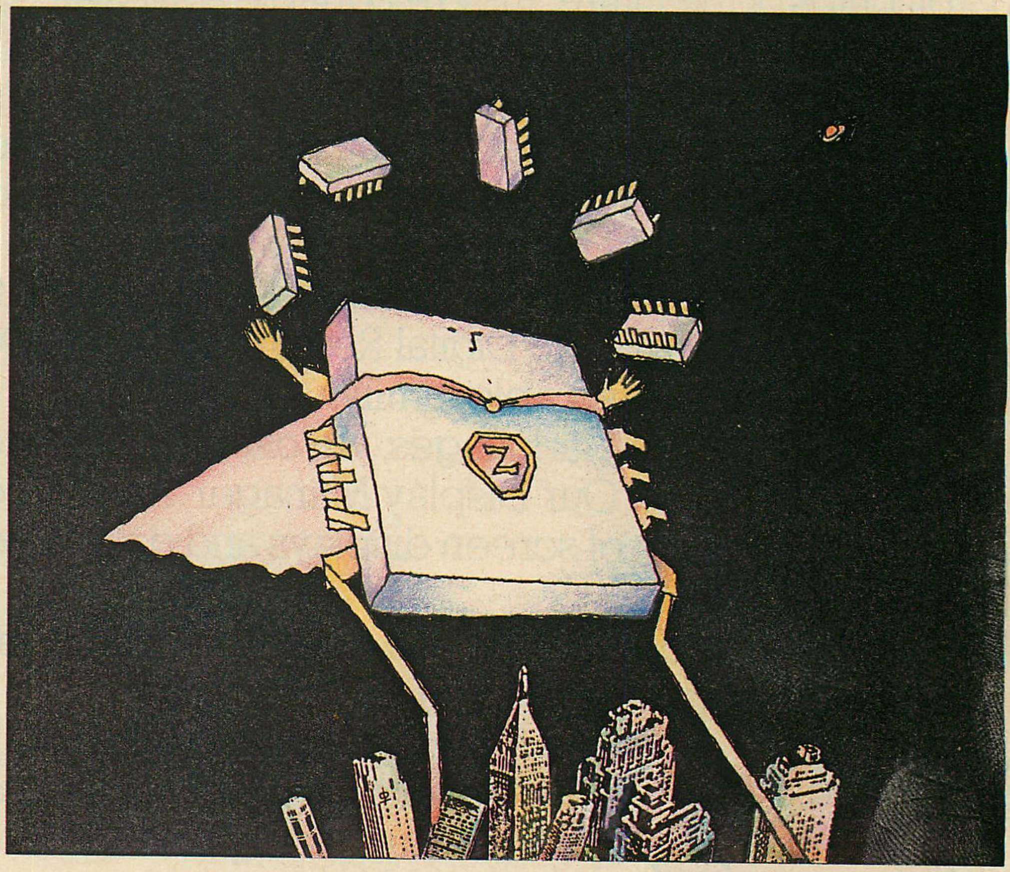


ILLUSTRATION • DAVID POVILAITIS

Random Rumors and Gossip

IBM is expected to introduce a new 640-by-400 pixel, 8-color video controller card shortly. Speculation is that the board will be made for IBM by Intelligent Systems Corp., Norcross GA. **IBM** is expected to formally announce its local area network product for linking PCs, XTs, and business systems this month, if not sooner. **IBM** is not expected to announce their new 80286-based multi-user version of the PC until late this year. The unit is expected to have a 20 Mbyte hard disk (with options for larger sizes) and to use the UNIX operating system. **IBM** is also rumored to be working on a 5.25" floppy drive that stores 1.6 Mbytes and that may be used as the standard drive on the next generation of PCs. There are also rumors that **IBM** has developed PC-based single-user prototypes of the Series 1, S/34, and S/36 machines and is working on a 3081 unit. These are rumored to be plug-in boards similar to the XT/370. **IBM** is expected to introduce a new version of the PC*jr* later this year, with an improved keyboard. **Compaq Computer** and **Kyocera,** the Japanese supplier of knee-top portable computers for Radio Shack, NEC, and Olivetti, are rumored negotiating a private label agreement for a new IBM-PC compatible knee-top portable. Radio Shack, Spectravideo, NEC, Commodore, and TI are also expected shortly to release IBM-compatible knee-top machines with 80 column displays. Also expected as options are battery-operated compact disk drives and printers. **IBM** is expected shortly to introduce a PC version of the Textpack word processor used on its Displaywriter system. It is expected to use a new keyboard and to be an initial step toward replacement of the Displaywriter with a PC version. Expectations are that **Microsoft** will shortly release MS-Net, a networking extension for PC/MS-DOS. There are reports that several ISVs (Independent Software Vendors) and OEMs (Original Equipment Manufacturers) have had beta-test versions of both MS-Net and MS-Windows for several months and are adding facilities to their packages to take advantage of these extensions to MS/PC-DOS. These companies are, among others, DEC, Wang, HP, Data General, Zenith, Ashton-Tate, Software Arts, Peachtree, Lotus, Software Publishing, Context, Management Systems, and Micro Focus.

IBM Announces UNIX for PC

As previously rumored in this column, IBM has introduced a Unix operating system for the PC/XT. The big surprise is that IBM did not go with Microsoft's Xenix. Instead, the company chose to have Interactive Systems Corp. of Santa Monica, CA transport to the PC its implementation of Unix for VAX machines. The operating system will be called "Personal Computer Interactive Executive," or "PC/IX." IBM is expected to start shipping it this month.

PC/IX is an implementation of Unix Version 3, not the current Unix System V being heavily promoted by AT&T as the new standard for Unix. PC/IX is a single-user implementation of Unix, which is really intended to be a multi-user operating system. Thus most industry experts expect that this announcement is a precursor of a new multi-user PC system that should appear late this year.

Microsoft is expected to do a port of AT&T's UNIX System V and to release it early next year. IBM is using Microsoft's Xenix (an implementation of Unix Version 7) on its 68000-based CS-9000

News, views, and gossip on the IBM and IBM-like marketplace

microcomputer, which is marketed by the company's instruments division.

DRI Drops CP/M-86-PLUS

CP/M-86-PLUS, a greatly enhanced version of CP/M-86 that Digital Research, Inc. has had in beta testing for several months, will not be released for sale. The new version would have offered the features currently available in CP/M-80-PLUS. Reports from the beta-test sites were that this would have been the fastest DOS available for 8088/8086 systems with many enhancements.

In dropping CP/M-86-PLUS, after investing several man-years of work in it, DRI is conceding that CP/M-86 has achieved too limited a market to justify the expense of introducing and supporting a new version of it. Rather, DRI will concentrate its efforts on its new windowing version of Concurrent CP/M-86 (CCP/M-86), which was demonstrated at the Comdex show last November and which should have been released by the time you read this column. The new CCP/M-86 will also be capable of running all PC-DOS software that follows proper interfacing rules. IBM will probably market this new version.

CP/M-80-PLUS, for 8-bit machines, was released almost a year and a half ago by DRI and has met with limited acceptance, despite the extended features and speed enhancements it offers. Only a handful of OEMs have adopted it, with most users being content to run the old Version 2.2 of CP/M-80, more than 2 million copies of which have been sold. DRI is also releasing a new version of CP/M-80 to be called Personal CP/M; the system is intended for low-cost home computers using Z80 microprocessors. It is also expected that Zilog will soon release a new version of the Z80 microprocessor chip itself. And late this year Zilog is expected to introduce a "super" Z80 chip, to be called the Z800, that will add powerful features such as memory management and hardware multiply/divide, etc. Thus CP/M-80 is expected to continue as a popular microcomputer disk operating system for many years to come, dominating the 8-bit micro world.

XT Supply Eases While PC Shortages Continue

Dealers are reporting that IBM has caught up on orders for XTs, so these machines are now readily available from dealers' stocks. Some dealers are even offering significant discounts on the XT and holding special promotions—for example, some of them are including a color monitor or software with the XT. On the other hand, PCs are still reported not readily available, with dealers still receiving fewer machines than they order.

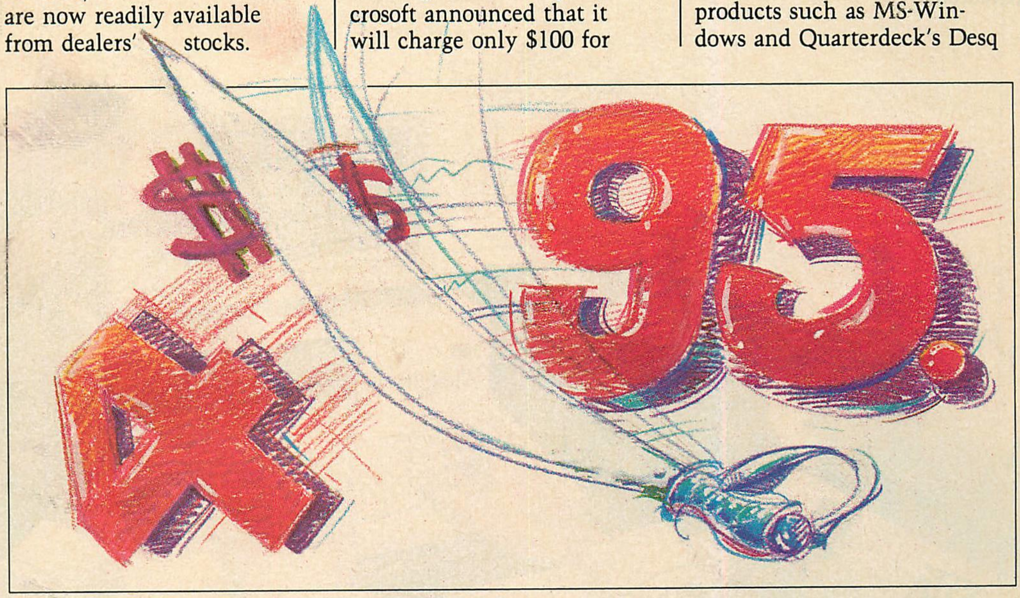
The general consensus is that sales of XTs have flattened because many potential customers are holding off, expecting that IBM will soon announce a 20-Mbyte version of the XT. There is also speculation that IBM switched production from the PC to the XT, on which they make more profit.

VisiOn Price Slashed

VisiCorp has slashed the price of its new VisiOn windowing software from $495 to $95—now that is slashing! But then again, Microsoft announced that it will charge only $100 for MS-Windows, which is due out shortly. VisiCorp's announcement came only one month after it started shipping the package and represented a recognition that the product is just not selling.

VisiOn is a closed system that requires that applications packages be specifically written for it. VisiCorp has begun shipping software development kits to software houses, but at this time there is no third-party software available to run under it. VisiCorp has released its own Word, Calc, and Graph software at a package price of $995, which if bought separately would cost $1295. The cost of the mouse pointing device—$295—must be added to this, making the total cost for VisiOn about $1,400. Further, VisiOn really runs well only on a system with a hard disk, so a typical complete system will be in the area of $6,500, far out of the range of most home users and many business users.

On the other hand, products such as MS-Windows and Quarterdeck's Desq ($399) are expected to work with off-the-shelf software. To protect its position, VisiCorp is aggressively pushing to establish VisiOn in the marketplace before these other products become available.



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IBM Sues Two Rivals on PC-ROM Copyright

IBM filed copyright-infringement suits against Corona Data Systems and Handwell Corp., charging they copied the software contained in the BIOS ROM of the IBM PC and used it in "look-alike" machines. The companies quickly reacted by agreeing to cease marketing machines using the code. Handwell is a California importer of Taiwanese machines.

Apple computer has set an industry precedent by filing suits against more than 50 companies (most outside the U.S.) charging similar copyright infringement. One case, against the U.S. micro manufacturer Franklin Computer, dragged on through the courts for more than two years; Apple finally won, and Franklin agreed to cease producing the chips and to pay Apple damages. However, a virtual flood of Apple II computer copies has been arriving from Taiwan, Korea, and Europe. The U.S. Customs service has confiscated many of these machines, but many have also gotten through. Thus, it is common to see Apple II clone computer kits being sold at computer hobbyist flea markets for about one-third the list price of Apple's machine. It is likely that the same will happen with the IBM PC.

Predictions

Industry prognosticators are predicting that IBM will make between 1.5 and 2 million IBM PCs this year. If the company can do it, this will mean that by the end of this year there will be between 32.3 and 2.8 million IBM PCs in operation. The number of IBM PCs will then have exceeded the number of Apple II machines sold and will be approaching the number of Commodore C64 machines sold. Of course, in dollar terms, IBM PC sales are almost equal to sales of the Apple II and C64 combined.

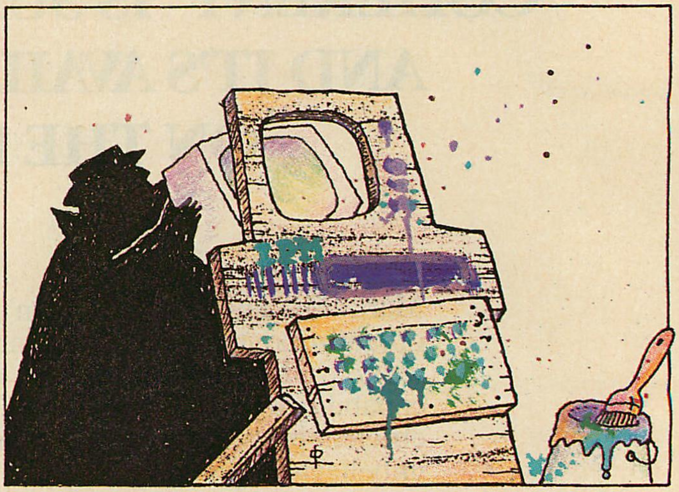
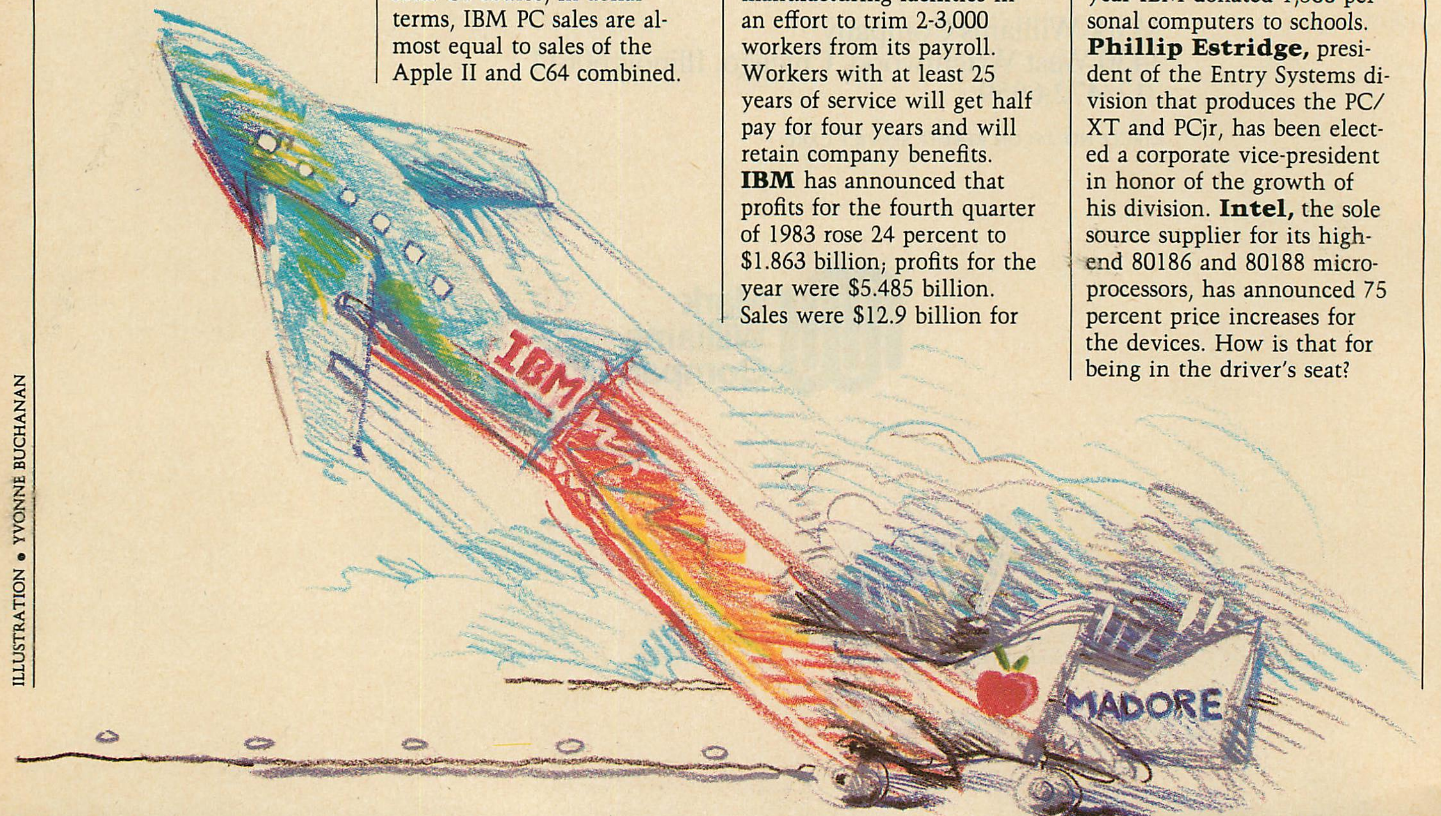


ILLUSTRATION • DAVID POVILAITIS

Random News Bits

MicroPro International, producer of the popular WordStar word processor system, will shortly go public. The company reported sales of $45 million for fiscal '83 and profits of almost $5 million. **IBM** has initiated a "voluntary resignation" employee program, similar to that at AT&T, at five major manufacturing facilities in an effort to trim 2-3,000 workers from its payroll. Workers with at least 25 years of service will get half pay for four years and will retain company benefits. **IBM** has announced that profits for the fourth quarter of 1983 rose 24 percent to $1.863 billion; profits for the year were $5.485 billion. Sales were $12.9 billion for the quarter and more than $40 billion for the year. Profit margins for the year improved from 10.89 percent to 12.7 percent. **IBM** has hiked its stake in Intel to 17.5 percent from 15 percent. An agreement between IBM and Intel permits IBM to own as much as 30 percent. **IBM** has promised to donate 2,000 PCs and PCjrs, worth $12 million, to 130 schools as part of a program to improve computer education. Last year IBM donated 1,500 personal computers to schools. **Phillip Estridge,** president of the Entry Systems division that produces the PC/XT and PCjr, has been elected a corporate vice-president in honor of the growth of his division. **Intel,** the sole source supplier for its high-end 80186 and 80188 microprocessors, has announced 75 percent price increases for the devices. How is that for being in the driver's seat?



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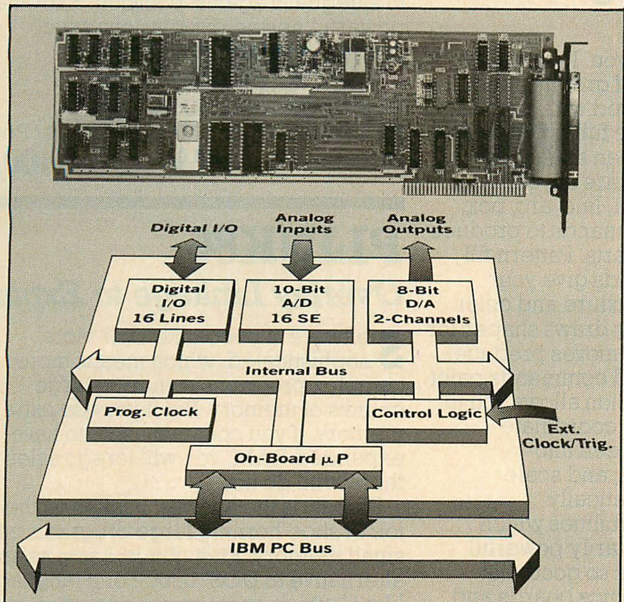

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It's a long list of capabilities which make for an extraordinarily powerful product. In fact, Halo is so good that manufacturers of graphics boards and systems are adopting it as a standard graphics language. So it can bridge your application to other systems. CAD-CAM developers, especially, have embraced its device-independent approach for maximal portability.

Halo is a dazzling demonstration of why C has become the language of choice among programming professionals: its function library architecture means you can tremendously enhance your firepower by acquiring libraries of software like Halo with dramatic economy of time and money.

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It has a format mode for tab setting or wraparound and shaping when it's time to write documentation. Pmate lets you assign chains of commands or strings of text to single keys: one keystroke could set up the entire shell of a new C function, for example.

Pmate has variables, if-then statements, loops. It calculates, and converts decimal to hex to binary and back. You can write compact programs (called "macros") to delete comments, for example, or check syntax, or process long sequences of commands. Macros can alphabetize lists, do row and column math, perform a series of operations on multiple files, even summon other macros.

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Unlike other linkers, the overlay manager acts on its own, needing no calls from the source program. Instead, Plink86's straightforward overlay description language allows you to describe your overlay structure in one place in your program — a structure

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Plink86 is a two pass linkage editor. On the first reading it determines all modules which need loading, to insure greater flexibility in assigning memory segment addresses before the disk file is created on the second pass. It can even sub-divide its linked output into multiple files for programs which must span more than one disk.

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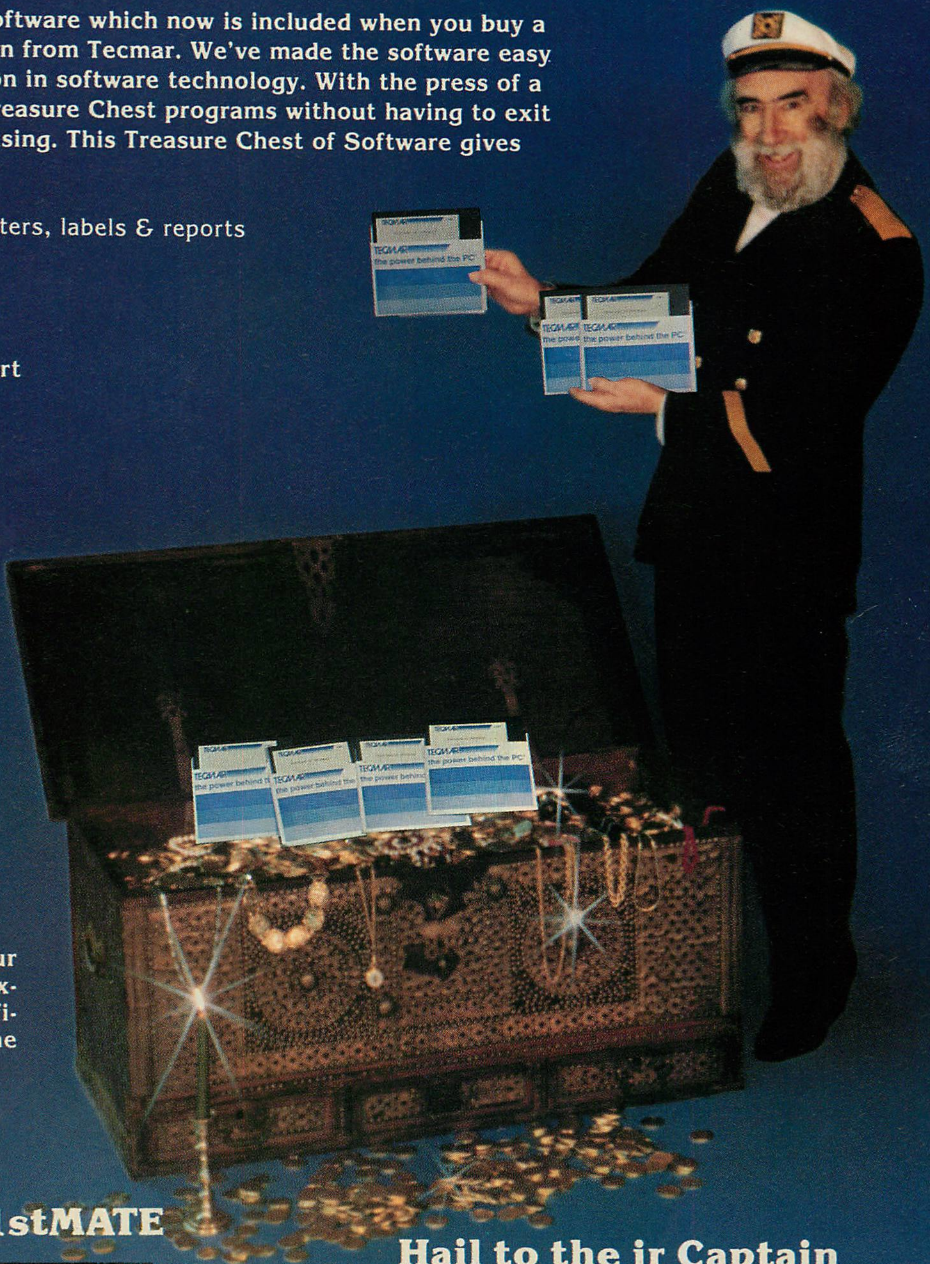

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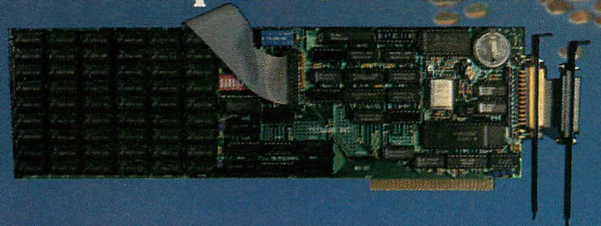

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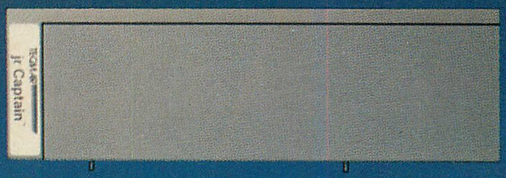

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Graphics for the IBM PC

A program for creating and rotating three-dimensional objects on the PC's graphics monitor

JAY MALLIN

With the graphics board installed, the IBM PC can display some impressive color graphics on a good monitor. Rainbows of colors, however, are not necessarily the most interesting results that can be produced using the graphics board. With a little programming, it's possible to add a new, third dimension to the PC's graphics.

DRAWING 3-D OBJECTS

The first trick in drawing three-dimensional objects is providing some method of describing the object to be drawn. One way to do this is to consider a line or arc as series of close but discrete points—after all, that's how they are drawn on a TV monitor—and then to store the *X*, *Y*, and *Z* coordinates of each of those points.

The problem is that to perform some mathematical manipulation on the figure—rotating it around the Z axis, for example—it is necessary to perform that manipulation on each of those discrete points. Anyone who

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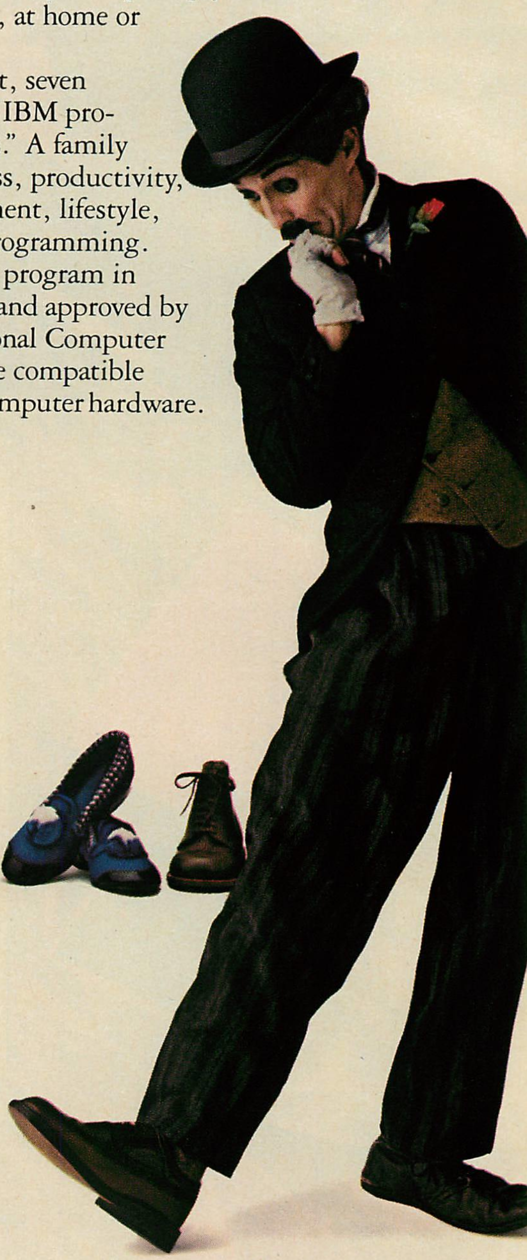

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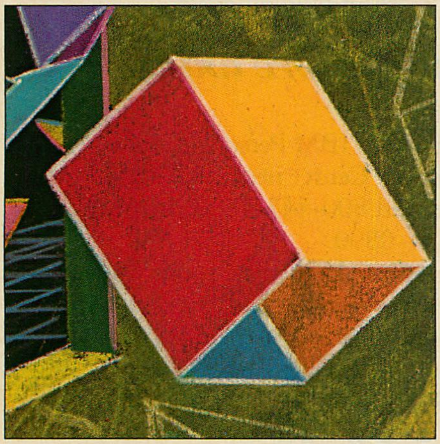
has worked much with the PC's interpretive BASIC knows that speed isn't its forte. Performing an operation on each of several thousand pieces of data would require hours, and that delay would be repeated each time a user asked the program to rotate a figure a few degrees.

Luckily, what PC BASIC is missing in speed it makes up for in useful graphics commands. One—the LINE statement—provides a simple solu-



tion to dealing with thousands of discrete points, so long as the user is willing to give up curves, or at least to build them out of line segments.

This method, used in listing 1, works as follows. A cube, for example, is described by giving the program the coordinates of its eight corners and indicating which of the points are connected by lines. The eight points can quickly be put through the necessary mathematics to rotate the figure in space. Once the program knows where the points are after a given rotation, it uses the line information to connect the appropriate points and draw the cube.

After all, no matter how a cube is turned, two corners that are connected by an edge are always connected by that edge. And no matter what the perspective, that edge always appears to be a straight line, although it may be foreshortened a bit.

The next problem is to rotate the points in space. The method for doing this is usually expressed in matrix notation. Figure 1 shows the matrix needed to rotate a point i degrees around the Z axis, where x, y, and z are the coordinates of the point to be rotated. The matrix result of this multiplication gives the new coordinates of the point after it has been turned around the Z axis i degrees.

PC BASIC does not support matrix operations, of course, so the multiplication in figure 1 needs to be rewritten. That's easy enough to do:

$$x = x\cos i - y\sin i$$
$$y = x\sin i + y\cos i$$
$$z = z$$

Similarly, to rotate j degrees around the Y axis:

$$x = x\cos j + z\sin j$$
$$y = y$$
$$z = z\cos j - x\sin j$$

and k degrees around the X axis:

$$x = x$$
$$y = y\cos k - z\sin k$$
$$z = y\sin k + z\cos k$$

It's possible to multiply the three matrices together to get one large rotation matrix, but they are much easier to work with separately.

The last problem is displaying the three-dimensional object on the screen, which is easy to do. In listing 1 it's done simply by ignoring coordinates for one axis—the X axis—when drawing the figure. This projects the figure onto the flat surface of the screen, squashing it flat.

There also are some housekeeping details involved in turning the three-dimensional coordinate information into two-dimensional information used for drawing on the screen. One is adjusting for the upside-down coordinate system used in the BASIC graphics commands; another is compensating for the distortion produced by having 640 pixels horizontally and only 200 vertically.

Luckily, what PC BASIC is missing in speed it makes up for in useful graphics commands. One—the LINE statement—provides a simple solution to dealing with thousands of discrete points, so long as the user is willing to give up curves.

USING THE THREED PROGRAM

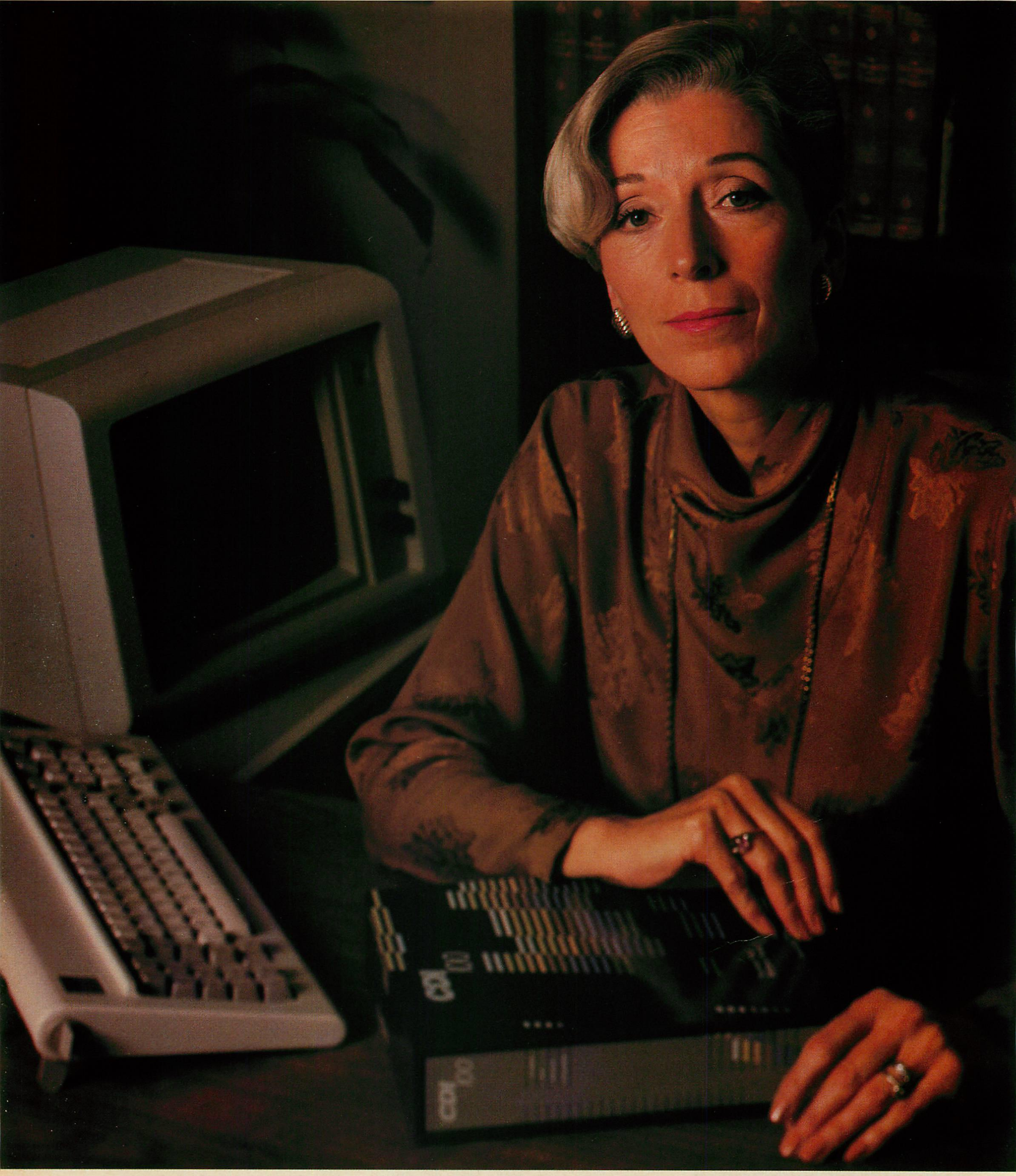
The following information about using the THREED program in listing 1 will help those people who don't want to take the time to write a better program. (Every programmer knows he or she can write better programs than anyone else; it's just time constraints that force programmers to use someone else's work.)

The program accesses disk files with the extension .3D that contain the information needed for each picture. I've written a BASIC program to create the files, but its listing is longer than that for THREED and equally good results can be obtained by using the DOS EDLIN program.

The data files have a three-part structure. The first part, a single line, simply tells the program the number of points described by the file. Next is the listing of each of the points—remember, we are interested only in points to be connected by lines. There are no statements in the program to display single points, though that can be changed if desired. The points are described one on each line, with x, y, and z coordinates being separated by a comma.

The last part of the file tells the program each line that is to be drawn. The points mentioned above are considered numbered from 1, and each line of this portion of the file holds two numbers, separated by a comma; these are the numbers of the endpoints that are to be connected by a drawn line.

This process sounds more complicated than it really is. For examples of data files for drawing three-dimensional figures, see listing 2, which



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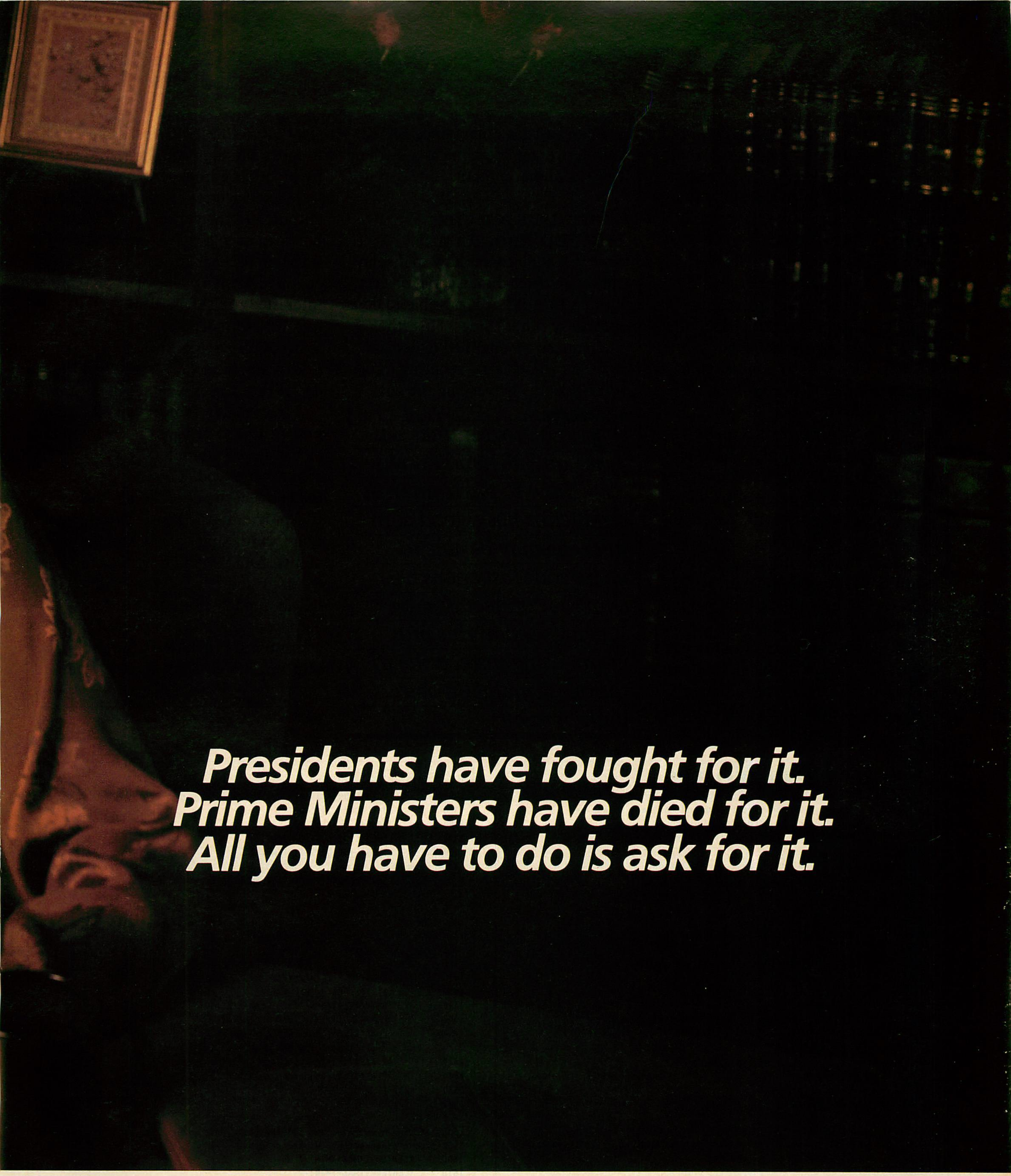

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draws a cube; listing 3, which draws a diamond; and listing 4, which draws a pyramid.

Remember to give any file that is created the extension .3D so the program can find it. And when describing an image, don't worry about making it the right size or centering it on the screen. The program will do that by itself. When the picture file has been loaded, the program will draw the image on the screen and ask for the desired *X*, *Y*, and *Z* rotations. The drawing is oriented so that (although the axes are not actually drawn on the screen) the *Z* axis is vertical, the *Y* axis is horizontal, and the *X* axis is perpendicular to the screen—running from the center of the monitor to the user's eyes.

After the user has entered the rotation he wants, the program will redraw the figure and ask for a new rotation. A word of advice: it is frequently easier to rotate around just one axis at a time if it is desired that the object end up in a specific position. Input 0 degrees for the two axes around which the figure should not rotate or just hit Enter, since BASIC considers Enter the same as a 0 when it wants numeric input.

OTHER USES FOR THE THREED PROGRAM

Once it is understood how to display and rotate three-dimensional objects with an IBM PC, it is possible to do a number of other things. First, the program can be modified to expand or shrink the object—zooming in or pulling back—by varying the constant 90 in line 1740. It's also possible to move the figure to the right or left by modifying lines 1840 and 1850.

If a programmer has an 8087 and knows how to program in assembler or has a good compiler, he may be able to write code fast enough to skip the connect-the-dot scheme used in this program, using instead the rotation formulas on objects built of points.

A pen plotter can be attached for output, and the concepts discussed here can even serve as the basis for a software package for CAD (Computer-Aided Design). One area anyone interested in CAD will want to look into is the hidden-line problem—how to avoid displaying lines on the other side of an object that would be hidden if that object were solid.

If a programmer has an 8087 and knows how to program in assembler or has a good compiler, he may be able to write code fast enough to skip the connect-the-dot scheme used in this program, using instead the rotation formulas on objects built of points. And if he likes to watch his PC draw and redraw rotated objects, he can modify the BASIC program to use a constant or random rotation continuously, sending objects tumbling dizzily through space forever.

Jay Mallin is a graduate student in electrical engineering at the University of Florida.

Listing 1 THREED.BAS

```
1000 'Program to display and rotate three-dimensional images on
1010 'IBM PCs with graphics cards.
1020 'File:  THREED.BAS   (c) 1983 Jay Mallin
1030 '
1040 'Initialize variables, arrays; set up screen.
1050      KEY OFF
1060      PI=3.141593
1070      DIM ROT(2,2),LINES(149,1)
1080      SCREEN 2
1090      ON ERROR GOTO 2580
1100 '
1110 'A data file with point and line info is loaded from disk.
1120     CLS
1130     PRINT "Here are the picture files stored on disk."
1140     FILES "*.3d"
1150     INPUT "Enter the name of the file you wish loaded:  ",NAM$
1160     NAM$=LEFT$(NAM$,8)
1170     OPEN NAM$+".3d" FOR INPUT AS #1
1180 '
1190 'The first number in the file tells the number of points it holds.
1200     INPUT#1,LENGTH
1210     LENGTH=LENGTH-1
1220 '
1230 'The array XYZ will hold the three coordinates of each point,
1240 'and XY holds the x,y coordinates used for drawing on the display.
1250     DIM XYZ(LENGTH,2), XY(LENGTH,1)
1260 '
1270 'Next follows the x, y, and z coordinates for each of the points.
1280     FOR I=0 TO LENGTH
1290         INPUT#1,XYZ(I,0),XYZ(I,1),XYZ(I,2)
1300     NEXT I
1310 '
1320 'After the list of points are stored pairs of numbers that
1330 'tell which points to connect with lines.  The array LINES
1340 'contains the pairs of endpoints of each line to be drawn.
1350     LINECOUNT=-1
1360     WHILE LINECOUNT<149 AND NOT(EOF(1))
1370         LINECOUNT=LINECOUNT+1
1380         INPUT#1,TEMP1,TEMP2
1390         LINES(LINECOUNT,0)=TEMP1-1
1400         LINES(LINECOUNT,1)=TEMP2-1
1410     WEND
1420     IF LINECOUNT>149 THEN PRINT "More than the allowed
       149 lines in file."
1430 '
1440 'The figure is centered, then proportioned to fit on the screen.
1450 'The first step is to find the largest and
1455 'smallest values of x,y, and z.
1460     XMAX=XYZ(0,0)  : YMAX=XYZ(0,1)  : ZMAX=XYZ(0,2)
1470     XMIN=XMAX      : YMIN=YMAX      : ZMIN=ZMAX
1480     FOR I=1 TO LENGTH
1490         IF XYZ(I,0)>XMAX THEN XMAX=XYZ(I,0)
1500         IF XYZ(I,1)>YMAX THEN YMAX=XYZ(I,1)
1510         IF XYZ(I,2)>ZMAX THEN ZMAX=XYZ(I,2)
1520         IF XYZ(I,0)<XMIN THEN XMIN=XYZ(I,0)
1530         IF XYZ(I,1)<YMIN THEN YMIN=XYZ(I,1)
1540         IF XYZ(I,2)<ZMIN THEN ZMIN=XYZ(I,2)
1550     NEXT I
1560 '
1570 'A "center" is found between the greatest and smallest values for each
1580 'of the three axis, and all the coordinate values are adjusted to move
1590 'those centers to be at the origin.
1600     XCENTER=(XMAX+XMIN)/2
1610     YCENTER=(YMAX+YMIN)/2
1620     ZCENTER=(ZMAX+ZMIN)/2
1630     FOR I=0 TO LENGTH
1640         XYZ(I,0)=XYZ(I,0)-XCENTER
1650         XYZ(I,1)=XYZ(I,1)-YCENTER
1660         XYZ(I,2)=XYZ(I,2)-ZCENTER
1670     NEXT I
1680 '
1690 'The largest value of all the newly adjusted coordinates is found,
```


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```
1700 'and that is used to scale the picture to stay within the screen.
1710     MAX=XMAX-XCENTER
1720     IF MAX<YMAX-YCENTER THEN MAX=YMAX-YCENTER
1730     IF MAX<ZMAX-ZCENTER THEN MAX=ZMAX-ZCENTER
1740     FACTOR=90/MAX
1750     FOR I=0 TO LENGTH
1760         XYZ(I,0)=FACTOR*XYZ(I,0)
1770         XYZ(I,1)=FACTOR*XYZ(I,1)
1780         XYZ(I,2)=FACTOR*XYZ(I,2)
1790     NEXT I
1800 '
1810 'With the 3D coordinate data in XYZ, build the 2D data
1820 'in XY that is used for drawing the picture on the screen.
1830     FOR PNT=0 TO LENGTH
1840         XY(PNT,1)=CINT(91-(5*XYZ(PNT,2)/12))
1850         XY(PNT,0)=CINT(320+XYZ(PNT,1))
1860     NEXT PNT
1870 '
1880 'Draw the lines, using the endpoint pairs stored in LINES
1890     LINE (0,0)-(639,183),1,B
1900     LINE (1,1)-(638,182),0,BF  'Clears top of screen.
1910     FOR I=0 TO LINECOUNT
1920         PTA=LINES(I,0)
1930         PTB=LINES(I,1)
1940         LINE (XY(PTA,0),XY(PTA,1))-(XY(PTB,0),XY(PTB,1))
1950     NEXT I
1960 '
1970 'Get the next rotation, or end the program
1980     LOCATE 24,1
1990     PRINT "Enter rotation in degrees for each axis,
       or enter 361 to exit program.";
2000     LINE (0,192)-(620,199),0,BF
2010     LOCATE 25,1
2020     INPUT; "X:  ", ROT(0,0)
2030     IF ROT(0,0)= 361 THEN 2440
2040     LOCATE 25,14
2050     INPUT; "Y:  ",ROT(1,0)
2060     IF ROT(1,0)= 361 THEN 2440
2070     LOCATE 25,27
2080     INPUT; "Z:  ",ROT(2,0)
2090     IF ROT(2,0)= 361 THEN 2440
2100 '
2110 'Convert the input to degrees; find sin and cos of each. All the
2120 'results are stored in ROT.
2130     FOR I=0 TO 2
2140             ROT(I,0)=PI*(ROT(I,0) MOD 360)/180
2150             ROT(I,1)=SIN(ROT(I,0))
2160             ROT(I,2)=COS(ROT(I,0))
2170     NEXT I
2180 '
2190 'Compute new coordinates in XYZ to rotate around the Z axis.
2200     IF ROT(2,2)=1 THEN 2280
2210             FOR PNT=0 TO LENGTH
2220                 TEMP=XYZ(PNT,0)
2230                 XYZ(PNT,0)=ROT(2,2)*XYZ(PNT,0)-ROT(2,1)*XYZ(PNT,1)
2240                 XYZ(PNT,1)=ROT(2,1)*TEMP+ROT(2,2)*XYZ(PNT,1)
2250             NEXT PNT
2260 '
2270 'Rotate around the y axis if the rotation is not 0.
2280     IF ROT(1,2)=1 THEN 2360
2290             FOR PNT=0 TO LENGTH
2300                 TEMP=XYZ(PNT,0)
2310                 XYZ(PNT,0)=TEMP*ROT(1,2)+XYZ(PNT,2)*ROT(1,1)
2320                 XYZ(PNT,2)=XYZ(PNT,2)*ROT(1,2)-TEMP*ROT(1,1)
2330             NEXT PNT
2340 '
2350 'Rotate around the X axis.
2360     IF ROT(0,2)=1 THEN 2420
2370             FOR PNT=0 TO LENGTH
2380                 TEMP=XYZ(PNT,1)
2390                 XYZ(PNT,1)=TEMP*ROT(0,2)-XYZ(PNT,2)*ROT(0,1)
2400                 XYZ(PNT,2)=TEMP*ROT(0,1)+XYZ(PNT,2)*ROT(0,2)
2410             NEXT PNT
2420     GOTO 1830
2430 '
2440 'The user has the option of viewing another picture.
2450     CLOSE #1
2460     LOCATE 25,1
2470     PRINT "Do you wish to load and see another display? (y/n):  ";
2480     TEMP$=INKEY$
2490     IF TEMP$="" THEN 2480
2500     IF TEMP$="y" OR TEMP$="Y" THEN PRINT TEMP$; :
       ERASE XYZ,XY : GOTO 1120
2510     IF TEMP$<>"n" AND TEMP$<>"N" THEN 2480
2520     PRINT TEMP$;
2530 '
2540 'The screen is returned to mode 0 and the program ends.
2550     SCREEN 0
2560     KEY ON
2570     END
2580 '
2590 'Error routines are provided to deal with disk access problems.
2600     IF ERR=52 OR ERR=64 THEN PRINT "Bad file name." : RESUME 1150
2610     IF ERR=53 THEN PRINT "Nonexistant file." : RESUME 1150
2620     IF ERR<>71 THEN CLOSE #1 : KEY ON : SCREEN 0 : ON ERROR GOTO 0
2630         PRINT "Drive not ready.  Do something about it, then push enter."
2640         INPUT"",DUMMY$
2650         RESUME
```

Listing 2
A Program To Draw a Cube

8	1,5
0,0,0	2,3
1,0,0	2,6
1,1,0	3,4
0,1,0	3,7
0,0,1	4,8
1,0,1	5,6
1,1,1	5,8
0,1,1	6,7
1,2	7,8
1,4	

Listing 3
A Program To Draw a Diamond

17	4,5
1,2.4142,1	5,13
2.4142,1,1	5,6
2.4142,-1,1	6,14
1,-2.4142,1	6,7
-1,-2.4142,1	7,15
-2.4142,-1,1	7,8
-2.4142,1,1	8,16
-1,2.4142,1	9,16
2,4.8284,0	9,10
4.8284,2,0	10,11
4.8284,-2,0	11,12
2,-4.8284,0	12,13
-2,-4.8284,0	13,14
-4.8284,-2,0	14,15
-4.8284,2,0	15,16
-2,4.8284,0	17,9
0,0,-8	17,10
1,2	17,11
1,8	17,12
1,9	17,13
2,3	17,14
2,10	17,15
3,11	17,16
3,4	^Z
4,12	

Listing 4
A Program To Draw a Pyramid

5	1,4
0,0,0	1,5
2,0,0	2,3
2,2,0	2,5
0,2,0	3,4
1,1,2	3,5
1,2	4,5

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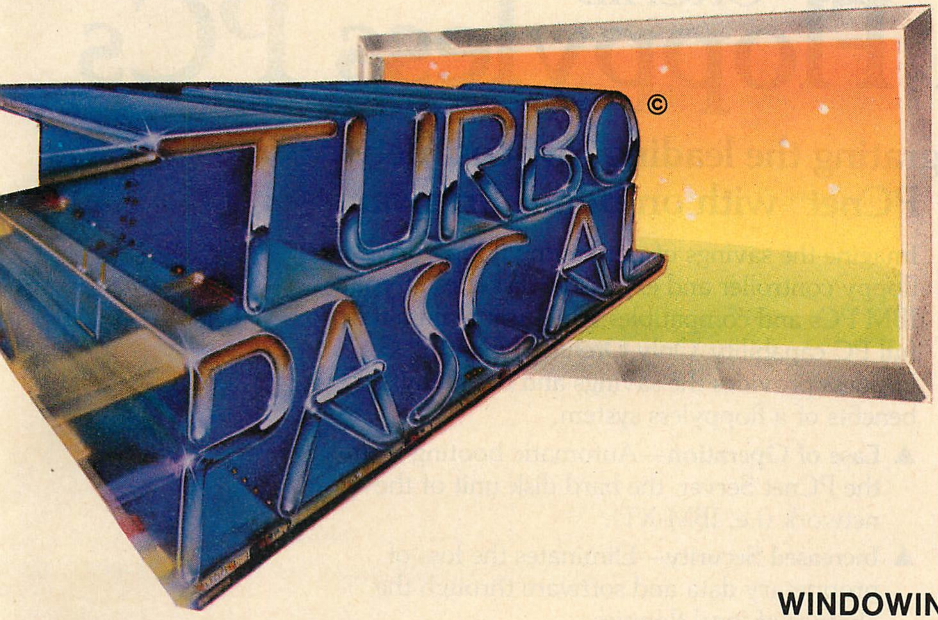

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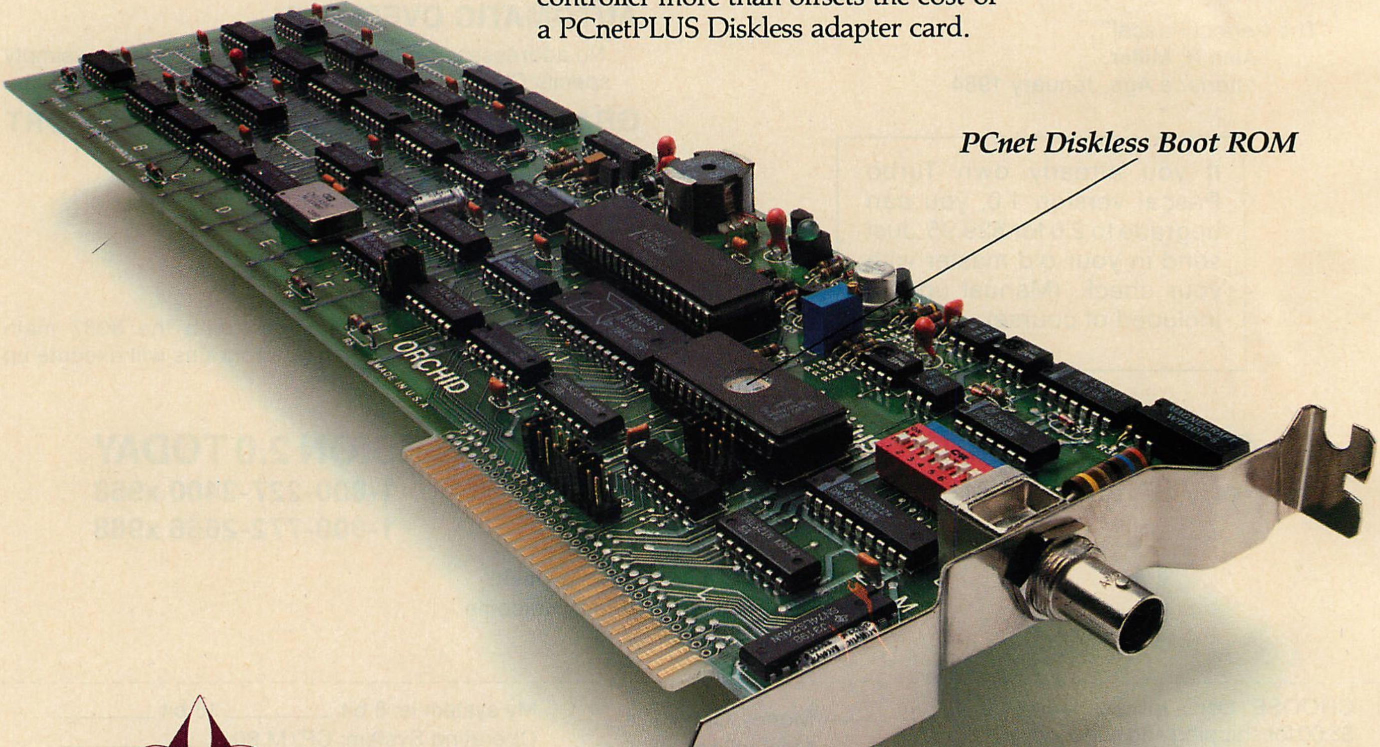

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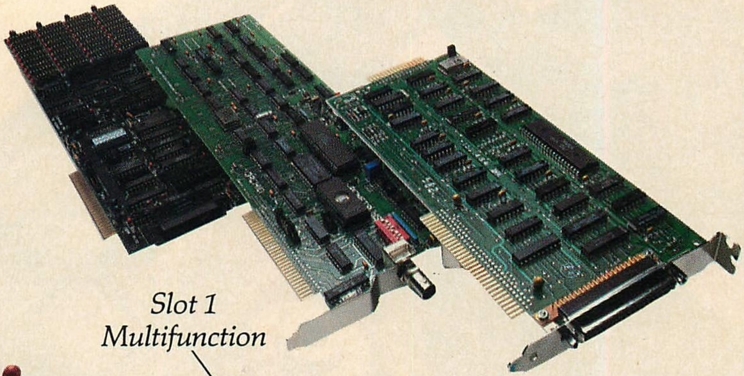

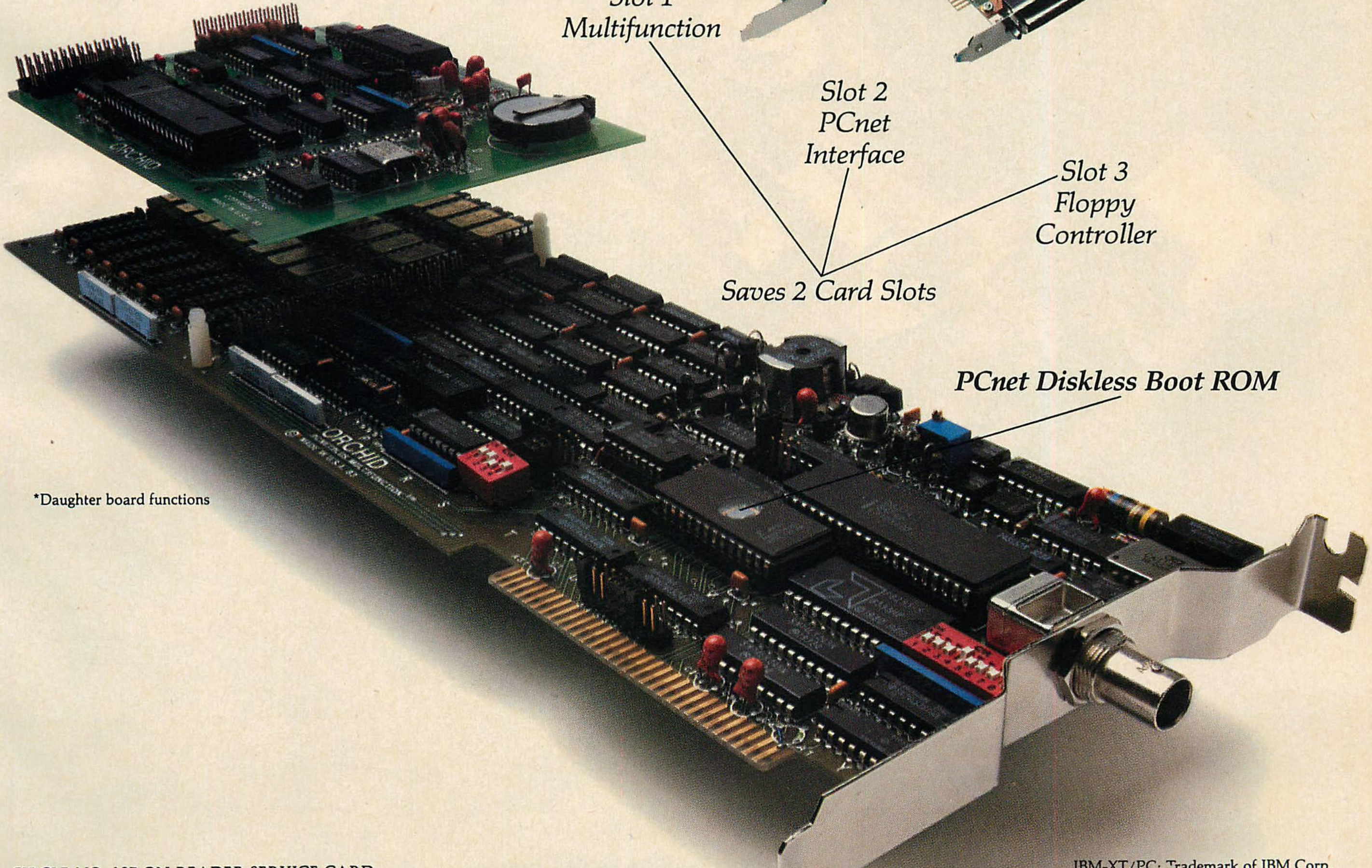

*Daughter board functions

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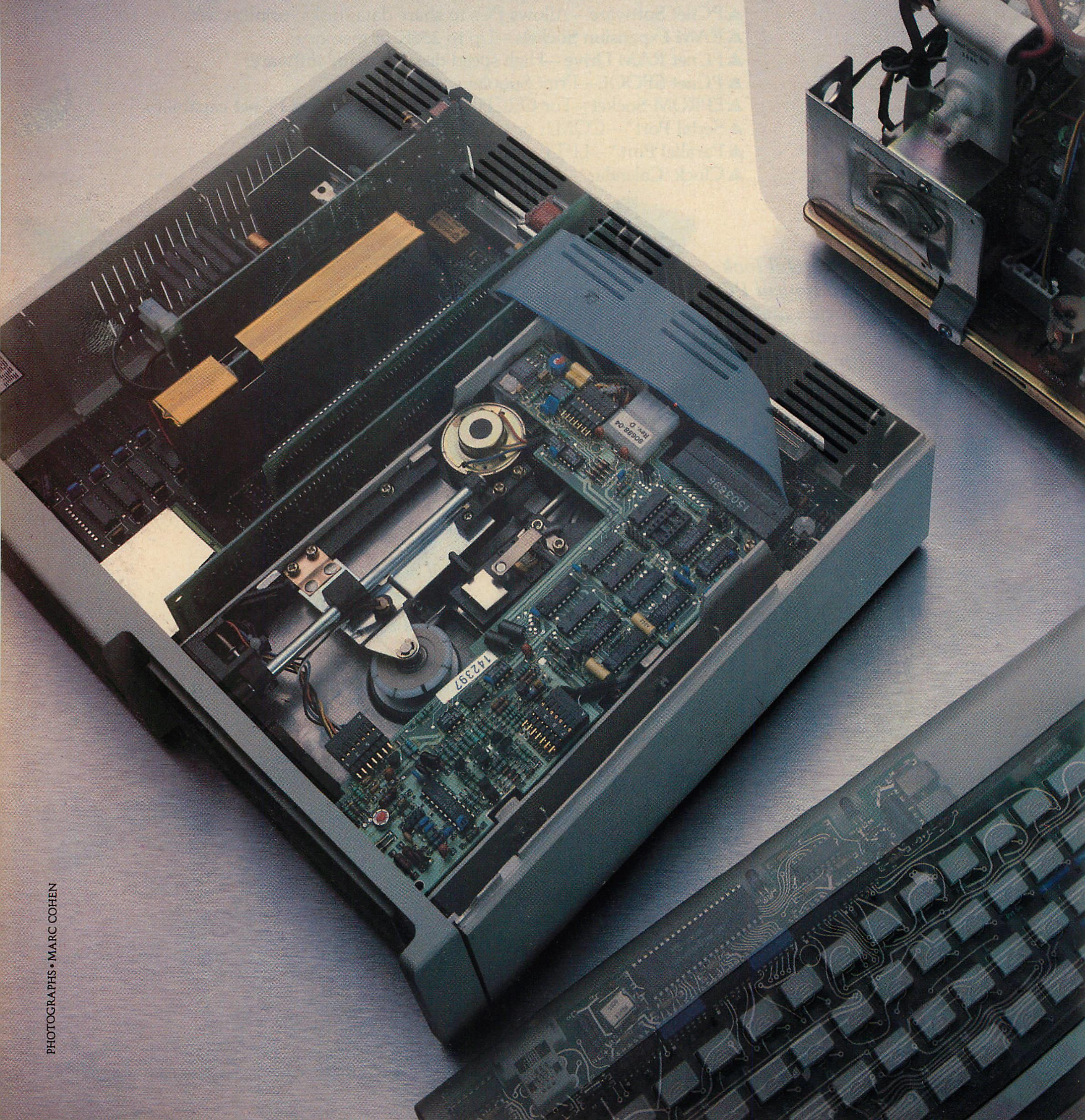
INSIDE *jr*

What makes IBM's home computer tick and why



PHOTOGRAPHS • MARC COHEN

Thomas V. Hoffmann

When I started work on this article, the PC*jr* was the newest and smallest member of the IBM PC family. With the introduction of the Portable PC, junior is no longer the new kid on the block, but he may still be the most interesting sibling in the burgeoning bunch. The PC*jr* is an unmistakable member of the family, extremely compatible in many ways and strikingly different in others (see table 1 for a comparison of features of PC*jr* and PC).

Those of you who read newspapers or watch television (did I leave anyone out?) already know the basics about PC*jr*. It's a lot smaller than the PC or XT, weighs less than 12 pounds, has a wireless infrared keyboard with cheap "Chiclet" keys, and comes in two models. The \$669 version has 64K of user RAM and no diskette drive. The \$1269 version has 64K memory and display expansion option, for a total of 128K of user RAM and one slimline 360KB diskette drive. The junior uses DOS 2.10, and its diskettes are totally compatible with those produced by the other PC family members. (For simplicity, I will use *PC* to refer to both the original PC—the 64K or the 256K version—and the PC/XT.)

Besides the diskette and memory expansion options, the PC*jr* line includes an internal 110/300 baud auto-dial, auto-answer intelligent modem (\$199). Each of these options mounts in a dedicated position inside the system unit. A parallel printer adapter is also available (\$99), which attaches to the bus expansion connector on the right side of the system unit and provides a standard

Thomas Hoffmann is a contributing editor to this magazine.

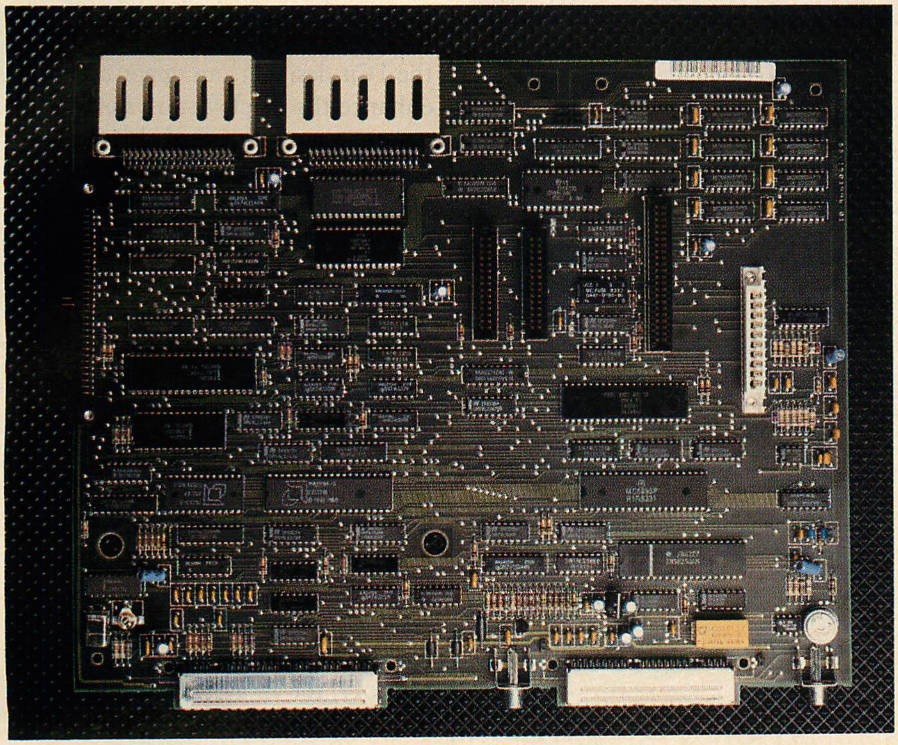
Although the PCjr is one of the more IBM PC-compatible machines on the market, it is far from 100-percent compatible with its predecessors.

Centronics printer interface compatible with the IBM Graphics Printer and a host of others.

IMPORTANT DIFFERENCES
Although the PCjr is one of the more IBM PC-compatible machines on the market, it is far from 100-percent compatible with its predecessors. Some of the differences are minor and will be invisible to the average user. Others are entirely new features. Still others are the result of important differences in implementation with major effects on performance and expansion. The list includes

- An entirely new system unit package, with unique peripheral connectors, dedicated internal option connectors, bolt-on bus expansion modules, and an external power transformer
- Self-identifying options that eliminate the need for user-settable configuration switches
- A wireless infrared keyboard, which, although it has only 62 keys, is nevertheless able to generate all of the codes obtainable from the standard PC 83-key keyboard
- A larger system board that integrates many PC-compatible features (display, RS232, joystick) that required separate option cards in the PC
- 64K of ROM on the system board. This ROM includes customer and advanced diagnostics in addition to BIOS and Cassette BASIC
- Provision for ROM expansion using plug-in program cartridges
- Enhanced display capabilities, featuring low- and medium-resolution graphics in 16 colors, high-resolution graphics in 4 colors, and all PC-compatible alpha and graphic modes. A flexible color palette allows any of 16 colors to be represented by any attribute in all modes. The display refresh buffer may be set anywhere in the first 128K of system memory
- An improved sound system that features a complex multi-voice sound generator and provision

Less than half the volume of the PC, PCjr is lighter and better looking. The reduction in size and weight is largely the result of the machine's two-part power supply.



IBM's conservative nature is evidenced by the design of PCjr's system board. The ample open space suggests that additional options, such as another bank of memory or a parallel printer port, could have been included with a tighter board layout.

for external audio input and output

– Seriously restricted implementations of diskette, keyboard, and communications I/O, such that simultaneous operation is severely limited
– Advanced BASIC features supported by a plug-in cartridge, not RAM-resident extensions
– A new revision of DOS (version 2.10) that is compatible with all three PC family members (PC, PC/XT, and PC*jr*).

I will explore these differences and their implications for system developers and advanced users.

Let's Get Physical

The most obvious characteristics that distinguish PC*jr* from PC are physical. The system unit is much smaller (less than half the volume of a PC), lighter, and better looking. The reduction in size and weight is largely the result of the machine's two-part power supply; an external transformer steps the line voltage down to 17 volts AC, and an internal printed circuit board produces the necessary DC voltages. IBM's decision to use plastic instead of metal for the system unit housing and to provide only one half-height diskette unit also helped keep the machine small and light.

The PC*jr* system board measures 10 by 13.8 inches (138 square inches) compared to the PC's 8.5 by 11 inches (93.5 square inches), and thus contains nearly 48 percent more area. Nearly half of the PC system board is devoted to memory (both ROM and RAM) and I/O expansion connectors. The same functions take much less space on the PC*jr* board, because the connectors are smaller, the ROMs are four times denser, and there is only 64K of RAM, without parity. These economies help provide space for the additional features that require separate option boards in the PC.

The basic PC*jr* system board contains the 8088 processor, 64K of ROM, 64K of RAM (without parity), an 8253 timer chip, an RS232 serial port, audio beeper, complex multivoice sound system, cassette interface, joystick interface, keyboard interface (infrared and hard wire), video graphics subsystem with enhanced features and light pen interface, connectors for internal and external options, two ROM cartridges (up to 128K bytes worth), and Input/Output bus expansion.

The original PC requires separate adapter cards for video, joysticks, RS232, additional memory, and diskette. Putting all that in one PC would consume all five expansion slots, leaving no place for the internal modem. The PC*jr* puts it all in one box, with enhanced sound and graphics capabilities that are simply not available on the PC, for considerably less money. Does this sound too good to be true? Well, there *are* certain compromises.

More is Less, Less is More, More or Less

The PC*jr* uses the same 8088 processor as the PC, running at the same 4.77 MHz speed, so it's just as fast, right? Wrong. Several things conspire to reduce junior's performance, all of them resulting from intentional marketing and engineering decisions. IBM's plans for the PC*jr* required certain cost and performance characteristics, so choices were made in an effort to position the PC*jr* at precisely the desired place in the PC spectrum.

The PCjr uses the same 8088 processor as the PC, running at the same 4.77 MHz speed, so it's just as fast, right? Wrong.

Table 1: PC vs. PCjr System Feature Comparison

Feature	PC	PCjr
8088 Microprocessor	Standard	Standard
8087 Math coprocessor	Optional	No
DMA Capability	Standard	Future
Control ROM	40K[1]	64K
BIOS	8K	16K
Cassette BASIC	32K	32K
Diagnostics	None	16K
Base memory (RAM)	64-256K	64-128K
Maximum memory (RAM)	640K	640K[2]
Cartridge slots	No	Standard
Monochrome display attachment	Optional	No
Color/Graphics adapter	Optional	Standard
Light pen interface	Optional[3]	Standard
Joystick interface	Optional	Standard
Cassette interface	Optional[4]	Standard
Diskette interface	Optional[5]	Optional
Fixed disk interface	Optional[6]	Future
Parallel printer attachment	Optional	Optional
Serial port	Optional	Standard
Baud rate (maximum)	9600	4800
Keyboard (number of keys)	83	62

Key
Standard = included in base system
Optional = available add-on to system unit
External = available add-on outside system unit
Future = provision exists for future attachment

[1]Plus socket for 8K additional ROM
[2]Must be added outside system unit, via I/O expansion connector
[3]Included with Color/Graphics option
[4]Not present on PC/XT
[5]Standard on PC/XT
[6]Standard on PC/XT

The effects of these choices have serious implications for users, software developers, and manufacturers of add-on hardware.

The following factors all reduce the actual or potential performance of the PCjr:

- the 8088 processor is configured in minimum mode, which saves logic but prevents use of the 8087 coprocessor
- the base 128K RAM is shared between processor and video circuitry, resulting in slower RAM access for instructions and data
- there is no DMA capability on the system board, so diskette transfers require the full attention of the processor and may not be overlapped with keyboard input or communications
- there is no deserialization hardware in the keyboard interface; thus, significant processor overhead is required to decode serial input from the keyboard.

IBM's decision to configure the processor in minimum mode is permanent—an 8087 cannot be added to the expansion bus. The absence of the 8087 has no direct effect on performance, except to limit future uses. Obviously, software that requires the 8087 (IBM's APL system is one example) can't be used on the PCjr.

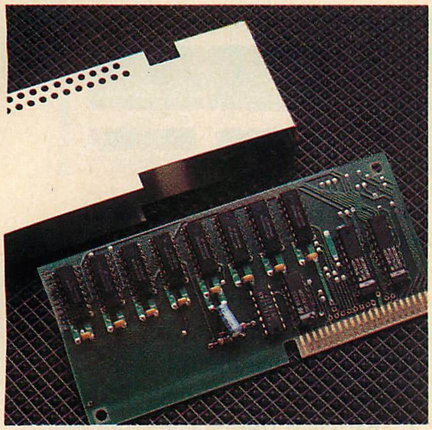
The integration of the video/graphics logic on the same board with the processor and memory gave the PCjr designers an opportunity to enhance the display subsystem by giving it access to all of the memory on the system board. This access allows more pages to be displayed and provides for additional modes that require more memory than the 16K available on the standard PC Color/Graphics adapter.

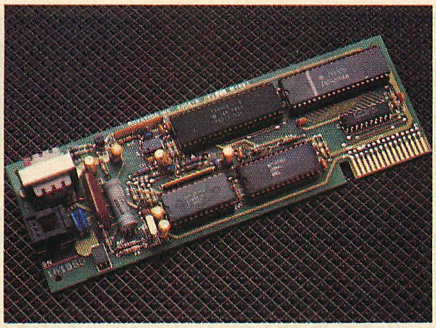
The RAM on the system board (and the 64K memory/display expansion option card) serves both as 8088 processor memory and display refresh memory. Ordinarily, processor accesses to memory take four 210-nanosecond clock cycles, or 840 ns. The display logic in the PCjr adds an average of two clock cycles to each RAM access in the first 128K of memory, for an average of 1260 ns per RAM bus cycle. This 50 percent slowdown in RAM access is significant and noticeable, especially since most programs running with DOS are entirely RAM-resident.

Dynamic RAM memory chips like those used in the PC and PCjr must be periodically accessed to avoid losing the information stored in them. This process is called *refreshing*. In the PC, a direct memory access (DMA) controller chip on the system board is used to generate the refresh cycles. The DMA mechanism is also used to transfer data between memory and diskette or fixed disk without processor intervention.

The PCjr does not have a DMA controller (though there is provision for adding DMA devices to the I/O expansion bus). This means the pro-

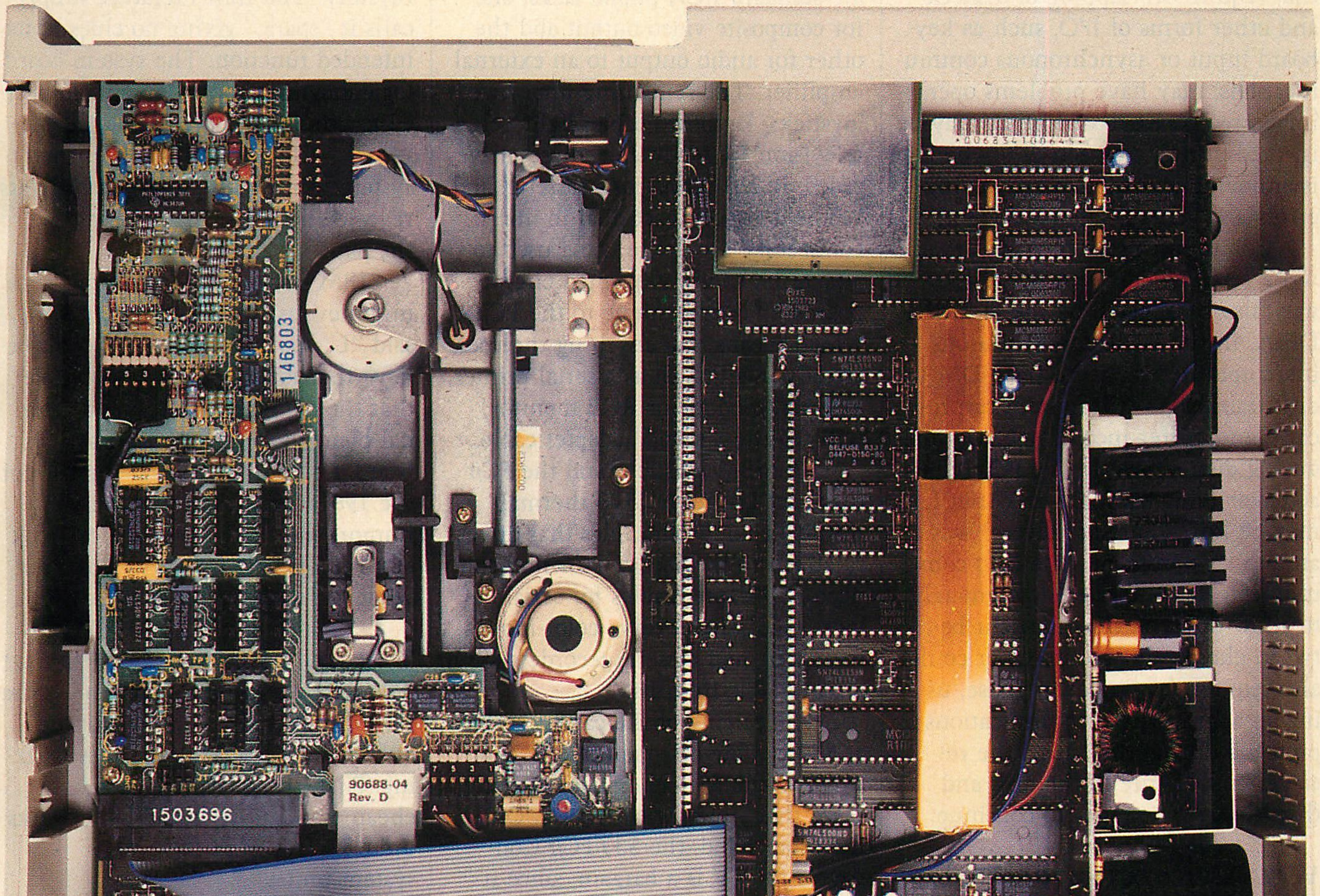
Even when the system cabinet is full, it is not crowded. All this open space, coupled with the extensive ventilation slots in the case, should allow PCjr to keep its cool.



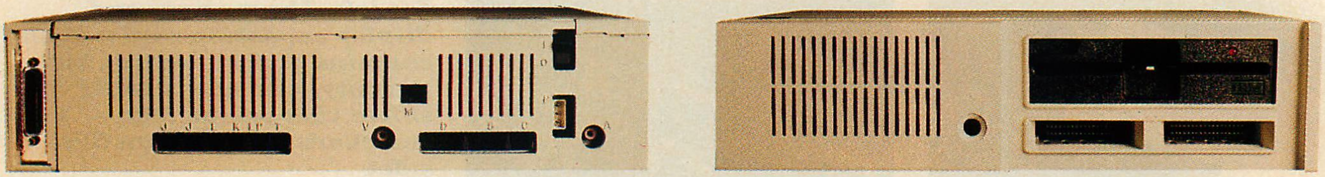


***Far left:* The memory and display expansion card (which contains almost nothing but memory) also sports an RF shield that completely surrounds the board on five sides.**

***Left:* IBM's internal modem is quite compact, yet as intelligent as most fully-featured modems. It occupies a dedicated slot in the junior's chassis.**



The worst part about the keyboard for those of us who are not touch typists is the coloring and placement of the key legends: white on a light gray background just above each key.



Front and rear panels of PCjr. The rear panel sports 13 connectors for peripherals and the power supply. The parallel printer option (not shown here) attaches on the left side.

cessor must devote its full attention to performing disk transfers. To ensure that nothing interferes with the byte-by-byte transfers, all other I/O interrupts are masked off during diskette transfer operations. Programs that require overlapping of diskette and other forms of I/O, such as keyboard input or asynchronous communications, may have problems operating correctly. Keyboard input may be ignored during disk activity, which is annoying and can lead to keying errors and general mental disruption.

Communications programs that write received data to diskette files may also be affected by the lack of DMA. In the PC, communications interrupts are enabled during DMA disk transfers, so the system can receive and buffer incoming characters during disk writes. In the PC*jr*, characters arriving during a disk transfer may be lost. There are several ways around this problem. One is to communicate at baud rates slow enough to allow disk transfers to occur between characters. The receiver could also request the sender to pause, using an appropriate communications protocol; during the pause, the receiver could write to the disk and then signal the sender to continue.

WELL CONNECTED, OR WELL, CONNECTED?

The rear panel of the PC*jr* system unit sports 13 connectors for attaching various peripherals and the external power supply. The power connector is mounted on the power supply board, just below the on/off switch. On the modem card is a standard RJ11 modular jack for attaching to the telephone network. The other 11 connectors are mounted directly on the system board. Two of them are standard RCA phono jacks, one for composite video output and the other for audio output to an external amplifier. The remaining nine (two joysticks, keyboard cable, light pen, television RF modulator, direct drive video, RS232 serial port, cassette, and "spare") are compact dual in-line connectors, similar to those used to attach flat cables to printed circuit boards; they are unique to the PC*jr*, which means that anything the user already owns, such as a serial printer, external modem, or RGB monitor, will require a special adapter cable.

The IBM joysticks and the PC*jr* Compact Printer (a $175 thermal printer) come with cables that directly attach to the special PC*jr* rear connectors. Adapter cables for serial devices ($25), direct drive color monitors ($20), and cassette recorders ($30) are available from IBM.

The pricing of the cassette cable at $30 is a big disappointment, compared to the $5 Radio Shack cassette cable that works with the PC. On the other hand, the $30 PC*jr* Connector for TV is a bargain, since it contains an RF modulator that looks exactly like the Sup'R'Mod models for the PC, which normally retails for $70.

The parallel printer adapter has a standard 25-pin D connector exactly like the ones on the PC printer adapters, and thus the adapter can use standard parallel printer cables.

The five-pin connector labeled "L" between the joystick and keyboard connectors is something of a mystery. The IBM literature simply calls it "spare," giving no clues to its intended function. The system board logic diagrams show one pin connected to ground and the others labeled "spare." Close examination of the system board with a magnifying glass revealed no connections to any of the pins.

IBM staffers in Boca Raton, with mischievous twinkles in their eyes, said "L" stands for "later." I don't believe that for a minute. It's possible that the connections are in an internal plane of the multi-layer system board. Or could it be that the IBM of the 1980s has a corporate sense of humor, and the "L" stands for "look at all the people trying to figure out what the L stands for"?

TAKE THE KEYBOARD. PLEASE!

The wireless infrared keyboard is the PC*jr*'s most striking innovation, requiring and deserving the most striking. First, the good news. It's light, cheap, resistant to liquids, and works up to 20 feet from the system unit without a cable. Now the bad news. It feels lousy, and it's hard to use for anything resembling serious typing. That's not all bad, expecially if the user isn't trying to do word processing. Nonetheless, this is nobody's

idea of a quality keyboard.

I must admit to having changed my mind about the keyboard. My first impression was that a user could learn to deal with it on its own terms and would eventually be able to use it for serious purposes for moderate periods of time. The layout is sensible, the use of the function prefix key is straightforward and obvious, and the key spacing is exactly the same as on the standard PC keyboard. But alas, after perhaps a dozen hours, I find it too error-prone.

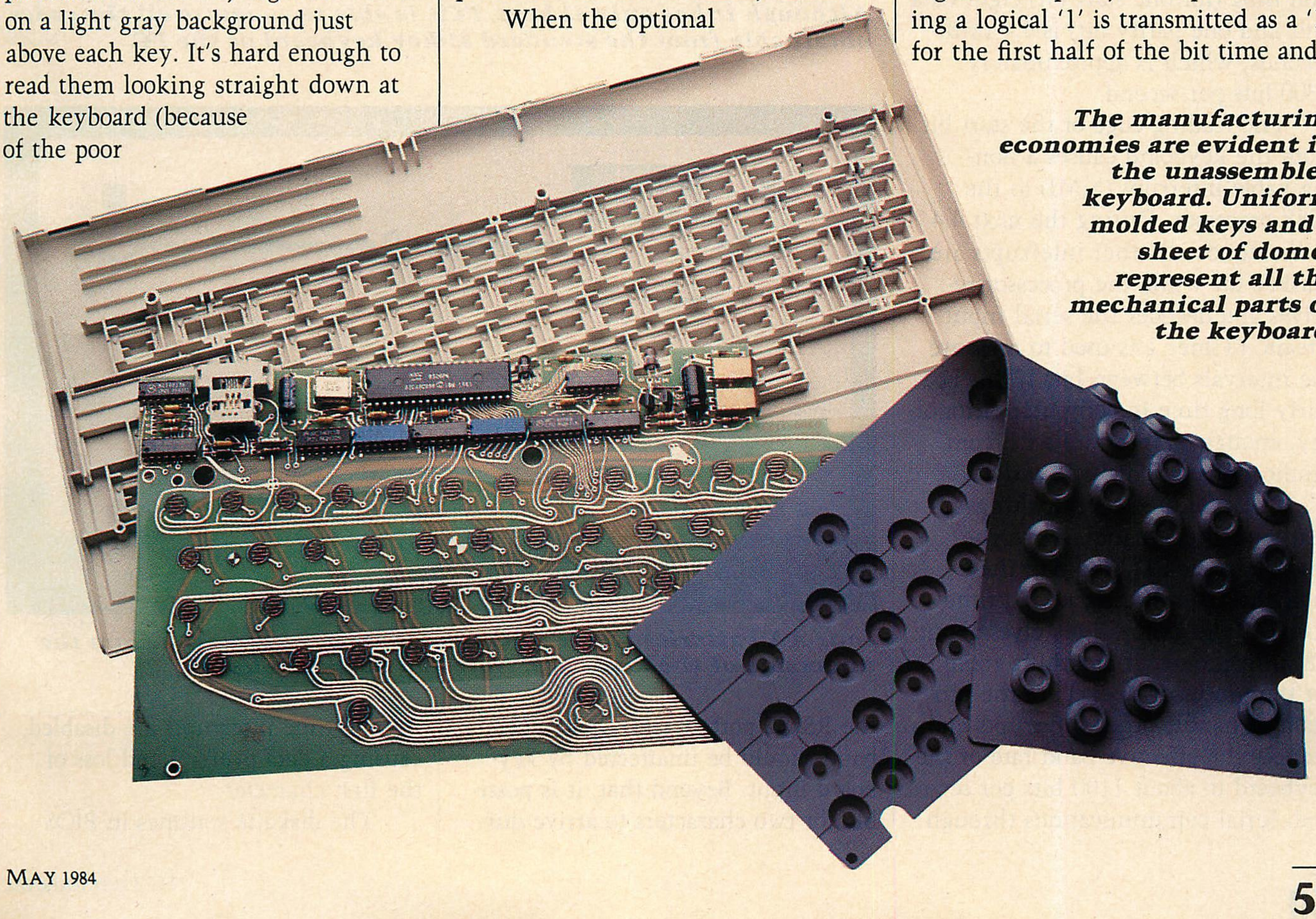
Part of the problem is the system's propensity to ignore keystrokes whenever processing them is inconvenient. Such occasions are signaled by a beep, which, though polite, is not conducive to speed and accuracy.

The worst problem with the keyboard for those of us who are not touch typists is the coloring and placement of the key legends: white on a light gray background just above each key. It's hard enough to read them looking straight down at the keyboard (because of the poor contrast between legend and background), but they disappear altogether with the slightest slouch. Third-party manufacturers have begun to address the keyboard problem, but at a fairly steep price (around $250; see related sidebar about one such product).

The PC*jr* keyboard does incorporate some interesting technical innovations. It uses a CMOS version of the Intel 8048 microcontroller (the standard 8048 is used in the PC keyboard) for low power consumption. Ordinarily the processor is in a standby mode to conserve the batteries. When a key is struck, the processor wakes up, scans the matrix, and transmits the scan code information to the system unit using the two infrared transmitter diodes at the rear of the keyboard. The keyboard has a local buffer; when it is empty, the processor returns to standby mode.

When the optional keyboard cable is used, the keyboard is powered directly from the system unit, and the batteries are disconnected. The cable disables both the infrared transmitter in the keyboard and the infrared receiver in the system unit; serial data is then sent over the cable. Since all PC*jr* keyboards transmit at the same frequency, the cable is required if multiple units are located in the same area (as in a classroom) or if conditions are not adequate for reliable infrared transmission. Bright lights and high voltage lines (including some TV sets) may interfere with infrared transmissions.

The infrared receiver in the system unit consists of an IR-sensitive photodiode, a two-stage amplifier, and a demodulator. The keyboard uses a simplex (one-way) communication protocol with biphase encoding and odd parity. In biphase encoding a logical '1' is transmitted as a '1' for the first half of the bit time and



The manufacturing economies are evident in the unassembled keyboard. Uniform molded keys and a sheet of domes represent all the mechanical parts of the keyboard.

At RS-232 speeds beyond 1200 bps, it is possible for two characters to arrive during the time interrupts are disabled, causing a data overrun.

as a '0' for the second half; a logical '0' is a '0' followed by a '1.' This allows an additional check on the integrity of the received data: if the first and second halves of the bit cell are not logically opposite, the cell is in error. This technique doesn't increase the reliability of the link, but it does reduce the likelihood of treating erroneous input as valid.

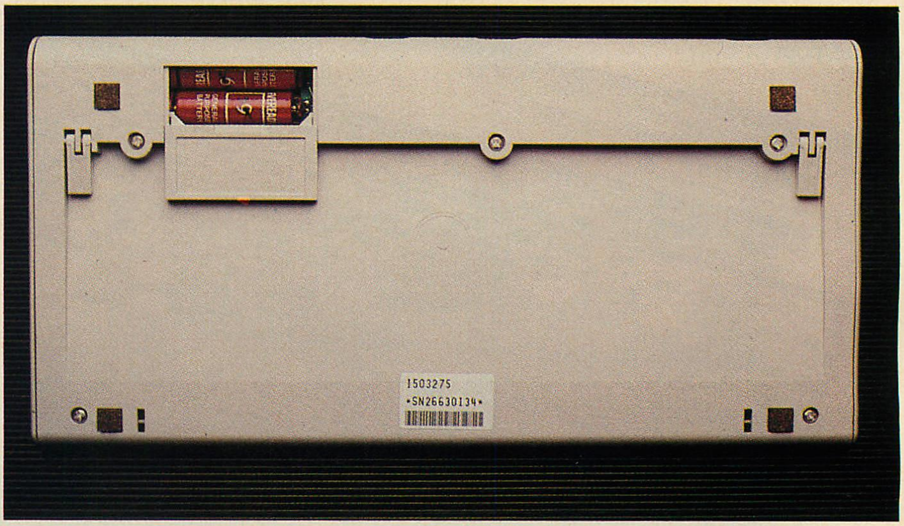
Figure 1 shows the encoding for keyboard transmission. A logical '1' on the IR link is a 62.5 microsecond burst at a 40KHz frequency at the beginning of the first half of the bit cell; a logical '0' is a similar burst at the beginning of the second half. The demodulator in the IR receiver transforms the burst into a logic '1' to look like the cable data, so the processor does only one kind of decoding. A bit cell is 440 microseconds long, so the character-transmission time (for one start bit, eight data bits, and one parity bit) is 4.4 milliseconds, which is approximately 2300 bits per second.

The leading edge of the start bit from the keyboard causes a nonmaskable interrupt (NMI) to the 8088 processor. During the next 4.4 milliseconds all other interrupts are masked off while the processor receives and decodes the serial input stream. (Timer 1 is used to measure the intervals between bits.) This is a fairly long time in computer chronology, enough to interfere with communications and diskette activity.

The PC*jr* does several things to deal with the situation. First, the keyboard sends 11 stop bits after each character, during which time no NMI will occur. This gives about 4.8 milliseconds of breathing room for the processor to execute the program or handle other interrupts and reduces the effective baud rate of the keyboard to about 1100 bits per second. Serial communications through the RS232 port at rates up to 1200 baud should be unaffected by keyboard input. Beyond that, it is possible for two characters to arrive during the time interrupts are disabled, causing a data overrun and loss of the first character.

The diskette routines in BIOS

Although it has only 62 keys, PCjr is able to generate all the codes obtainable from the standard 83-key keyboard of the PC.



Four AA batteries reside in the compartment accessed from the underside of the keyboard. Note the keyboard legs.

Figure 1: Keyboard Transmission Timing

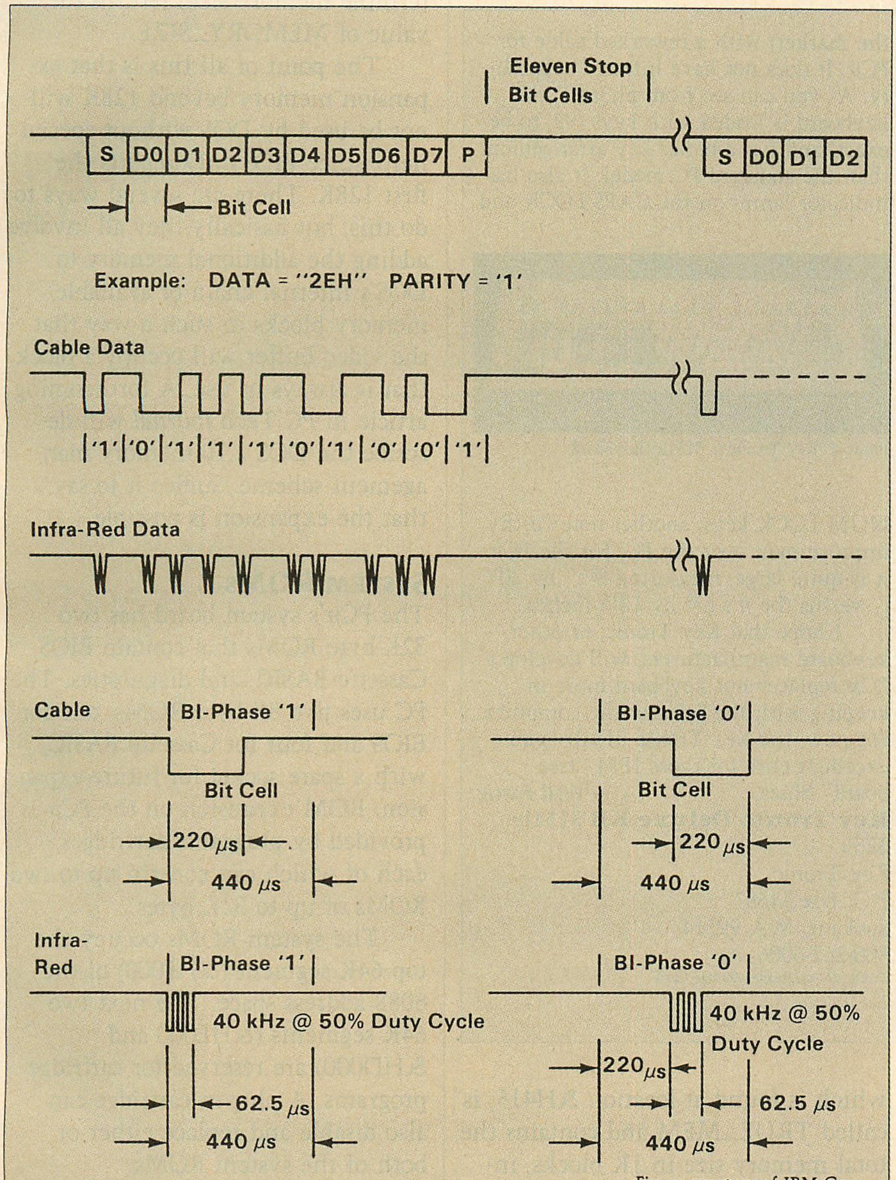


Figure courtesy of IBM Corp.

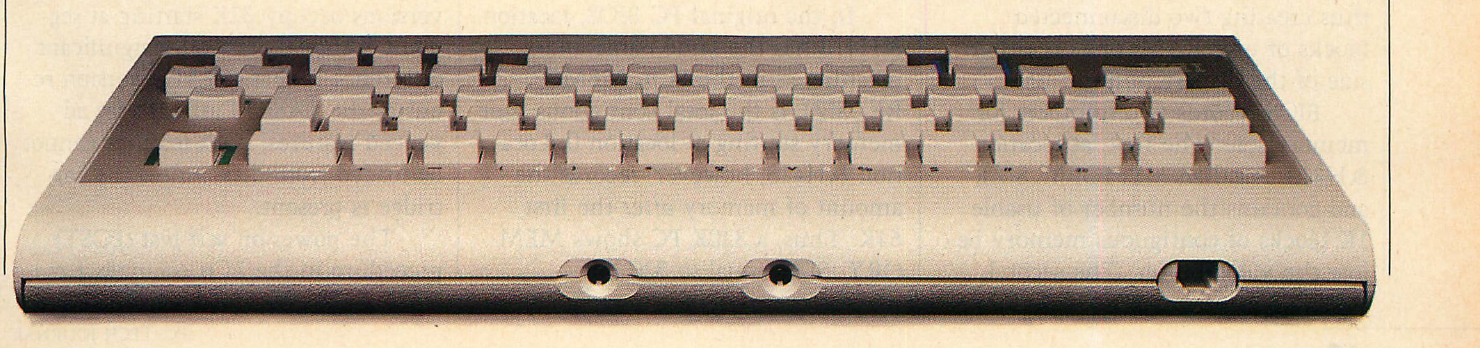
mask out all interrupts, including the keyboard's, to avoid interference from other I/O activity. Keyboard data is passed through a latch on the system board to allow the keyboard NMI handler to determine that bits arrived before the interrupt was able to be serviced. This condition is signaled by a beep, and the partial character is discarded.

Memory Organization

The PC*jr* allocates the 1-megabyte address space of the 8088 much as the PC does (see table 2). The first 640K of addresses are dedicated to user RAM, of which only the first 128K is currently available. This memory is shared between the processor and the display system.

For compatibility with PC applications that directly address the color/graphics display buffer at &HB8000, the PC*jr* maps references to addresses &HB8000 through &HBBFFF (as well as &HBC000 through &HBFFFF) to any specific 16K boundary in the first 128K. The CRT/Processor Page Register at I/O address &H3DF is used to specify the 16K pages for display and for mapping to &HB800.

During system initialization the PC*jr* BIOS reserves the last 16K of



The two openings near the center are infrared emitters. A socket for the optional keyboard cable is also shown.

The PCjr's system board has two 32K-byte ROMs that contain BIOS, Cassette BASIC, and diagnostics.

Solving the Keyboard Problem

It should come as no surprise to anyone that considerable criticism has been leveled at the PC*jr*. A veritable roar of catcalls, hoots, and jeers, however, has been directed at the PC*jr*'s keyboard.

What is strange about IBM's decision to use the "chiclet" style keyboard is that almost every other small computer, all less expensive than PC*jr*, has a full-stroke keyboard. Gone are the Atari 400's membranes. The new Radio Shack Color Computer boasts a good keyboard. Even the new Sinclairs have buttons now rather than the membrane.

Because IBM has a tendency to be unmovable in these things (the PC's keyboard also came under fire and is today unchanged), we can at least be gratified by the presence of third-party vendors. In this case, the company is Key Tronic, and the keyboard is its model KB 5151jr.

At $255, the 5151jr is a little steep for someone who has just bought a PC*jr*. If we think about a basic configuration of about $1,600, the new keyboard represents a premium of 16 percent. Of course, the keyboard is a dreamboat compared to the native version, so if the PC*jr* buyer plans to do a lot of typing, it might be a wise investment.

The 5151jr appears to be just the standard KB 5151 (Keytronic's deluxe replacement keyboard for the regular PC, which is priced competitively in the market) with a reworked cable for PC*jr*. It does not have infrared capability. As you can see from photo 1, the keyboard is loaded with keys (99, to be exact) and has a better key arrangement than the standard PC model. It also has indicator lamps on the CAPS LOCK and NUM LOCK keys, another noteworthy improvement over the PC. For the PC*jr* it is quite large, measuring 8½" by 20¼" versus the *jr*'s 6½ by 13¼ inches.

Photo 1: Key Tronics's 5151jr. Keyboard

I hope that Key Tronic, or other keyboard manufacturers, will develop a PC*jr* replacement keyboard more in keeping with the price of the computer. For now, the Key Tronic 5151jr is an excellent cure for those IBM "free-board" blues. —*Will Fastie*

Key Tronic Deluxe KB 5151jr
$255
Key Tronic
P.O. Box 14687
Spokane, WA 99214
800-262-6006
Circle 494 on Reader Service Card

base system memory for the video buffer, leaving either 48K or 112K for user programs. Any expansion RAM attached to the I/O expansion bus would be above the base 128K, thus creating two disconnected blocks of user RAM, one on either side of the display buffer.

BIOS records two numbers for memory size. The first, at location &H413, is called MEMORY_SIZE and contains the number of usable 1K blocks of contiguous memory below the video buffer. The second, which is found at location &H415, is called TRUE_MEM and contains the total memory size in 1K blocks, including the video buffer and any RAM in the I/O channel.

In the original PC BIOS, location &H413 has the same name and meaning as in the PC*jr*: MEMORY_SIZE is the total contiguous user memory starting at location 0. Location &H415, however, records the amount of memory *after* the first 64K. Thus, a 320K PC shows MEMORY_SIZE equal to 320 but IO_RAM_SIZE equal to 256. In both machines, BIOS function hex 12 (determine memory size) returns the value of MEMORY_SIZE.

The point of all this is that expansion memory beyond 128K will not be used by DOS without special help, since BIOS only reports the first 128K. There are several ways to do this, but basically they all involve adding the additional memory to DOS's internal chain of available memory blocks in such a way that the video buffer will occupy a block that is always in use. A forthcoming article in *PC Tech Journal* will describe the DOS 2.10 memory management scheme. Suffice it to say that the expansion is possible.

System ROMs

The PC*jr*'s system board has two 32K-byte ROMs that contain BIOS, Cassette BASIC, and diagnostics. The PC uses five 8K-byte ROMs, one for BIOS and four for Cassette BASIC, with a spare socket for future expansion. ROM expansion on the PC*jr* is provided by pluggable cartridges, each of which can contain up to two ROMs of up to 32K bytes.

The system ROMs occupy the top 64K segment (&HF000) of the 8088 address space. The next two 64K segments (&HE000 and &HD000) are reserved for cartridge programs. A plug-in cartridge can also disable and replace either or both of the system ROMs.

PC*jr* Cassette BASIC is nearly identical to PC Cassette BASIC. Both versions occupy 32K starting at segment &HF600. The only significant difference is that the PC*jr* version requires the BASIC Cartridge for advanced features; such features cannot be loaded from disk unless the cartridge is present.

The power-on self test (POST) procedure in the PC*jr* occupies a ma-

Table 2: PCjr I/O Address Map

Address	Usage
00000	64K Base RAM
08000	::
10000	64K Expansion RAM
18000	::
20000	512K Reserved for expansion RAM in I/O channel
28000	::
30000	::
38000	::
40000	::
48000	::
50000	::
58000	::
60000	::
68000	::
70000	::
78000	::
80000	::
88000	::
90000	::
98000	::
A0000	Reserved for future video RAM
A8000	::
B0000	Monochrome display memory (not on PC*jr*)
B8000	Color display memory (mapped to first 128K in PC*jr*)
C0000	Reserved for I/O ROM
C8000	(Fixed disk BIOS)
D0000	Optional cartridge ROM #2
D8000	Optional cartridge ROM #1
E0000	Standard cartridge ROM #2
E8000	Standard cartridge ROM #1
F0000	System board ROM #2
F8000	System board ROM #1

jor portion of the first 8K block of system ROM. First, the POST performs an extensive check of the PC*jr* hardware; then it determines the equipment configuration. Finally, it initializes the system. This process is much more extensive than the POST in the PC.

The POST is part of the PC*jr* manufacturing process, and there are provisions for outputting information about its progress (as well as errors) to unused INPUT/OUTPUT ports. The joystick input port (&H201) is used to determine whether normal initialization, manufacturing tests, or advanced technician tests are to be performed.

Whereas the PC diagnostics were provided on diskette, the PC*jr* diagnostics, both customer level and advanced, are contained in the system ROM. The major difference between the two seems to be the amount of detail in the error messages; the tests appear similar. The advanced POST is more extensive and takes more time than the normal initialization. Little plugs provided with the *Hardware Maintenance and Service* manual fit into the joystick connectors on the system unit to indicate service mode. Similar plugs are used during the manufacturing tests.

BIOS con Dios

The PC*jr* BIOS provides the same functions as the standard PC BIOS, plus a few more designed specifically for the PC*jr* (see table 3). The goal of BIOS has always been to provide a hardware-independent interface to system functions, provided that certain rules are followed. PC*jr* BIOS goes to some lengths to preserve that independence, even in situations in which there seems to be no need to be *that* compatible.

For example, many routines that should be accessed only through software interrupts are carefully placed at the same physical address as in previous PCs. It makes me wonder which IBM software products violated which rules.

Another bow to compatibility involves the handling of the 62-key keyboard. Previous PCs had the keyboard interface hardware connected to interrupt level 9, with the scan code available at input port &H60. As discussed earlier, the PC*jr* keyboard generates a nonmaskable interrupt (type 2) and requires the processor to do the deserialization.

The 62-key scan codes are received by the NMI handler. This handler then calls a conversion routine through software interrupt &H48, which converts the scan code to the 83-key keyboard equivalent. The conversion process includes remembering PC*jr*-specific shift states, such as the function prefix key that indicates that the top row of numeric is to be treated in the same way as the programmable function keys are on the 83-key keyboard. Finally, the conversion routine calls the standard 83-key keyboard handler through interrupt 9, which was the hardware interrupt for the old PC keyboard.

Some programs written for the PC installed their own keyboard interrupt handlers by changing the pointer in the vector for interrupt 9 and handling the keyboard at the scan code level after reading the code from input port &H60. Even these programs still work, because the INT 48 routine writes the converted scan code to port &H60 before calling INT 9. Now that's compatibility.

The vector for interrupt &H49 points to a translation table that is used to convert scan codes beyond the range of those sent by the keyboard to any value chosen by the programmer. This feature allows future devices (presumably infrared transmitters) to send data to the system unit and have it recognized as being from a nonkeyboard device. Wireless joysticks, musical instrument keyboards, and other similar devices likewise could be handled by this mechanism.

Several new functions have been added to BIOS specifically for the PC*jr*. These include setting the color palette registers in the video adapter, adjusting the repeat rate for typamatic keys, setting or clearing keyboard click, and selecting one of four inputs to the audio multiplexer.

PC*jr* BIOS contains character patterns for all 256 characters in the PC character set. The PC had ROM patterns for only the first 128 charac-

The PCjr design allows for several types of plug-in ROM cartridges, including I/O control, IPL, DOS commands, and interpretable BASIC.

ters, with interrupt &H1F reserved for users to supply patterns for the second 128. In the PC*jr*, interrupt &H1F points to the default patterns for the standard IBM characters 128 through 255. In addition, interrupt &H44 points to a character-pattern table for the first 128 characters, which may also be replaced by a user-supplied table. These tables are used in graphics modes to form the dot patterns for text to be displayed.

Cartridge ROMs

PC*jr* program cartridges allow ROM to be added to the system without removing the cover. Two identical slots in the front of the system unit are provided for ROM cartridges. Each slot has 15 address signals, to support ROM chips of up to 32K bytes each, and 6 chip-select signals that determine which of the top six 32K blocks each ROM addresses. Each cartridge has room for two ROM chips, for up to 64K bytes of storage.

Several different cartridge formats are supported by BIOS, DOS, and BASIC, all of which are similar to the format specified for I/O control ROMs such as the Fixed Disk BIOS on the PC Fixed Disk Adapter. All of the formats share a common header, which is used during system initialization to determine that a valid ROM addition exists.

This ROM initialization feature was added by IBM back in early 1983, when the XT and 256K motherboard PC were introduced, in order to support the fixed disk adapter. The BIOS in the original 64K PCs does not scan for ROMs, but it can be upgraded to do so. The upgrade chip is supplied with the PC expansion chassis to allow users to boot from the fixed disk.

Table 4 shows the PC option ROM formats used by the PC*jr* cartridges. At initialization, BIOS scans memory from segment &HC000 up to, but not including segment &HF000 in increments of 2K bytes, looking for the pattern '55 AA.' The next byte is interpreted as the length of the ROM module in 512-byte blocks. The last two bytes in cartridges are reserved for a cyclic redundancy check word.

ROM cartridges are checked using the same CRC algorithm as is used in IBM's SDLC communications protocol and PC cassette I/O. I/O control ROMs (below segment &HD000) are checked with a simple byte sum of all bytes in the module, which must be zero.

If the ROM module checks are successful, BIOS does a CALL far to location 3 in the module, which may contain a jump to initialization code or a far return. The initialization

Table 3: PC Family ROM BIOS Software Interrupts

ROM BIOS functions are accessed through software interrupts 10 through 1F. Vectors 40 through 5F are also reserved for BIOS use. Major functions show page numbers for routine listings in PC*jr* *Technical Reference*. Functions in **boldface** are unique to PC*jr*.

Interrupt Number	Major BIOS Function	Subsidiary Function (AH)
10	Video (A-29)	00 Set mode
		01 Set cursor type
		02 Set cursor position
		03 Read cursor position
		04 Read light pen position
		05 Set active text page
		06 Scroll up
		07 Scroll down
		08 Read attr/char
		09 Write attr/char
		0A Write char
		0B Set color palette
		0C Write dot
		0D Read dot
		0E Write TTY
		0F Current video state
		10 Set palette registers
11	Equipment check (A-97)	— Return equipment flag
12	Memory check (A-97)	— Return contig mem size
13	Diskette (A-74)	00 Reset disk system
		01 Read status
		02 Read sectors
		03 Write sectors
		04 Verify sectors
		05 Format track
14	Communications (A-63)	00 Initialize comm port
		01 Send character
		02 Receive character
		03 Return comm port status

15	Cassette (A-97)	00 Motor on 01 Motor off 02 Read blocks 03 Write blocks
16	Keyboard (A-43)	00 Read key 01 Check key available 02 Return shift status **03 Set typamatic rates** **04 Set/Clear keyboard click**
17	Printer (A-81)	00 Print character - 01 Initialize printer 02 Read printer status
18	Resident BASIC	— Entry to ROM BASIC
19	Bootstrap (A-26)	— System bootstrap
1A	Time of day (A-42)	00 Read clock 01 Set clock **80 Set sound multiplexer**
1B	Pointer to user keyboard break routine	
1C	Pointer to user timer tick routine	
1D	Pointer to video parameters	
1E	Pointer to diskette parameters	
1F	Pointer to character patterns (128-255)	
40	Reserved for Diskette I/O when fixed disk BIOS installed	
41	Reserved for pointer to fixed disk parameter table	
42-43	Reserved for BIOS	
44	**Character patterns (000-127)**	
45-47	Reserved for BIOS	
48	**Cordless keyboard translation routine**	
49	**Non-keyboard scan code translation table**	
4A-5F	Reserved for BIOS	
80-8F	**Used during PCjr POST and built-in Diagnostics**	

code typically modifies interrupt vectors so that the ROM can gain control later, then returns to BIOS. Some cartridges may retain control at this point (games such as Mouser do this), never returning to BIOS.

After initializing any ROM modules, BIOS attempts to boot from the diskette. If there is no diskette or if an error has occurred, BIOS executes an INT 18, which ordinarily goes to Cassette BASIC, unless a cartridge, such as Cartridge BASIC, has changed the vector to point to its own entry. Such cartridges are called IPL (for initial program load) cartridges.

Location 6 in a ROM module is used to indicate to DOS that additional DOS commands are contained in the ROM. If location 6 is nonzero, it is interpreted by DOS as the first in a sequence of command names and entry points. The format for this sequence is as follows:

- a byte indicating the length of the command name
- the command name in ASCII, with no terminator
- a near jump (3 bytes) to the command routine
- another command length/name/jump may follow; a length of zero indicates the end of the sequence.

Note that the PCjr *Technical Reference* describes this format incorrectly. It clearly states that the command name is followed by the two-byte offset of the command routine in the ROM segment, and even gives a detailed example. Nevertheless, the BASIC cartridge uses the format I have described above to implement BASIC and BASICA, and COMMAND.COM expects the same format (obviously, or it wouldn't work). Commands in ROM take precedence over commands on disk, so Cartridge BASIC is always invoked on a PCjr when the cartridge is present whether or not BASICA.COM or BASIC.COM is present on disk.

Command programs in ROM presumably return to DOS just like any other program, using an INT 20 or equivalent jump into the program segment prefix; however, I have not had an opportunity to verify this.

Both DOS 2.0 and DOS 2.1 look for ROM commands in the range &HC0000 to &HF0000, thus allowing commands to be added by I/O control ROMs as well as plug-in cartridges. Note that the search for cartridges is performed *only* if DOS determines the machine is a PC*jr*, based on the contents of the byte at F000:FFFE. IBM has defined the following values for the machine identification byte:

- FF Indicates original PC (and

Cartridge BASIC is a superset of Advanced BASIC, but requires no RAM to handle the additional statements.

Table 4: PC ROM Formats

Location	Contents	
I/O Control ROMs		
Location	**Contents**	
0	055H	Signature
1	0AAH	"
2	Length in 512-byte blocks	
3,4,5	Jump to initialize code	
6	0	
Last byte reserved for simple checksum		
IPL ROMs		
Location	**Contents**	
0	055H	Signature
1	0AAH	"
2	Length in 512-byte blocks	
3,4,5	Jump to initialize code	
6	0	
Last 2 bytes reserved for CRC		
DOS Commands		
Location	**Contents**	
0	055H	Signature
1	0AAH	"
2	Length in 512-byte blocks	
3,4,5	Jump to initialize code	
6	Length of command name	
7 to X-1	Command name	
X, X+1, X+2	Jump to command program	
X+3	Next length or 0 if no more commands	
Last 2 bytes reserved for CRC		
Interpretable BASIC		
Cartridge must be based at D000:0		
Location	**Contents**	
0	055H	Signature
1	0AAH	"
2	Length in 512-byte blocks	
3	0CBH	Far Return
4	055H	
5	0AAH	
6	0	
7	0FFH if unprotected, 0FEH if protected	
8	Tokenized BASIC statements	
n	0FFH padding to next 2048-byte boundary +½	
Last 2 bytes reserved for CRC		

some early XTs)

– FE Indicates PC/XT

– FD Indicates PC*jr*

The PC*jr* Cartridge BASIC has a provision for interpreting BASIC programs directly from another cartridge. This feature would be useful for software developers who write programs in BASIC and want to distribute them in cartridge form. A BASIC program cartridge must start at segment &HD000 and have a standard header with 'CB AA 55 00' in bytes 3 to 6. The interpretable BASIC code starts in byte 7, in the same form as it is written by the SAVE command. The cartridge should be padded with hex FF to the next 2048-byte boundary after the program.

Cartridge BASIC

The PC*jr* Cartridge BASIC provides a superset of BASICA (advanced disk BASIC), but unlike the disk-resident BASIC extensions, it requires no RAM for the code to handle the additional statements. Cartridge BASIC uses RAM only for the BASIC program and workspace. (BASIC programs in ROM cartridges are copied into RAM for interpretation.) PC*jr* Cassette BASIC requires that Cartridge BASIC be present before any extension can be loaded in RAM.

The Advanced and Disk BASICs supplied with DOS 2.1 are intended for the other PC family machines and do not implement any PC*jr* extensions. The PC*jr* Cartridge BASIC implements all of the features in Disk and Advanced BASIC, plus enhanced graphics and sound statements, but requires no diskette system for operation. Of course, none of the disk file functions are available without DOS. The disk also has a simple terminal emulation program, which acts as a dumb terminal through either the PC*jr* Internal Modem or the integral serial port.

Enhanced graphics support consists of four new modes for the SCREEN command, new statements (PALETTE and PALETTE USING) to control color mapping, and options on the CLEAR statement that allow the user to increase or decrease the amount of RAM dedicated to the

Controlling PCjr's Video Display

Programmers writing for the expanding IBM PC family may choose among three techniques for control of the video display. These methods offer varying degrees of hardware dependence and performance; each has pros and cons.

The first method, which performs all character I/O to the screen through standard PC-DOS service calls (software interrupt 21H), allows essentially complete hardware independence. Under PC-DOS 1.0 and 1.1, only teletype-like output capabilities were supported. In version 2.0 and 2.1, an optional ANSI console driver was added that allows the programmer to clear the screen, position the cursor, and select colors via standard escape sequences in the output stream. Performance using this method is poor; characters are transferred to the display screen at considerably less than 9600 baud equivalent. However, programs that employ this technique will run unchanged on any IBM PC model or, in fact, on any computer running a version of the MS-DOS operating system.

The second method, which involves direct calls to the ROM BIOS video driver through a software interrupt, results in considerably faster displays and provides primitive graphics capabilities. The program can write text or individual pixels and can also select display mode, palettes, and foreground/background colors. Programs that access the video display strictly through the ROM BIOS will run on any IBM PC model, though perhaps not on other MS-DOS-based machines, except for the so-called IBM clones.

Finally, programs may control the video display by writing directly to the video controller's registers and "regen buffer" (a dedicated memory area that holds information controlling the appearance of the display). This method yields the highest performance of the three but essentially locks the program to the hardware configuration. Programs written for the IBM PC or PC/XT using this method will not run properly only on the most compatible of the "clones" (e.g., the Compaq or Columbia).

The new PC*jr* contains a video controller that is considerably more sophisticated than the color/graphics board available for the IBM PC or XT. Among the new capabilities are vastly expanded palette control, three new graphics modes, user-definable character sets for *all* of the ASCII codes (only the upper 128 codes could be customized on the IBM PC), and dynamic control over which memory segment will be used as the regen buffer by the video controller. IBM significantly modified the software/hardware interface; corresponding changes and enhancements were made to the ROM BIOS's video driver. These changes are summarized below. As in the normal PC, access to the ROM video driver is obtained by placing a function number in register AH, loading other registers with function-dependent values, and executing a software interrupt 10H.

Function 0: Set Video Mode. Mode 7 (monochrome display on the PC or XT) is not valid on the PC*jr*. Three additional modes have been added:

8=160X200 16-color graphics
9=320X200 16-color graphics
10=640x200 4-color graphics.

Function 1: Set Cursor Type. Functionally the same as on the PC.

Function 2: Set Cursor Position for Selected Page. Functionally the same as on the PC.

Function 3: Read Cursor Position for Selected Page. Functionally the same as on the PC.

Function 4: Read Light Pen Positions. Functionally the same as on the PC.

Function 5: Select Active Display Page. Compatible with PC, but with added ability to read or set CPU and CRT page registers. The CPU page determines which part of the physical memory region 00000-1FFFFH will be mapped onto 16K of memory addresses starting at B8000H; no performance penalty is incurred by taking advantage of this address mapping. The CRT page determines the starting address of the physical memory used by the video controller to refresh the display. Smooth animation effects can be achieved through manipulation of these registers. Programs that write directly to the video map assuming a base address of B8000H can reach only the first 16 kbytes of the regen buffer; programs requiring direct access to the entire 32-kbyte buffer in modes 9 and 10 can obtain the current CRT page from the reserved word PAGDAT at offset 008AH in the ROM BIOS's data area.

Function 6: Scroll Up or Initialize Window of Active Page. Functionally the same as on the PC.

Function 7: Scroll Down or Initialize Window of Active Page. functionally the same as on the PC.

Function 8: Read Attribute and Character at Cursor in Selected Page. Functionally the same as on the PC.

Function 9: Write Attribute and Character at Cursor in Selected Page. Functionally compatible with the PC, with the additional capability of a user-defined character set for ASCII codes 00-7FH in graphics modes (the vector for interrupt 44H must be set to point to the user's bit table). User-defined character sets for ASCII codes 80-OFFH are installed by setting the vector for interrupt 01FH.

Function 10: Write Character Only at Cursor in Selected Page. Functionally compatible with the PC, with additional control of character color in graphics modes.

Function 11: Set Background and/or Border or Color Palette. Functionally similar to the PC; the definition has been expanded for 2-color and 16-color modes. See also new function 16.

Function 12: Write Pixel. Functionally compatible with the PC, but extended to support new graphics modes (transparent to user).

Function 13: Read Pixel. Functionally compatible with the PC, but extended to support new graphics modes (transparent to user).

Function 14: Write Characters in Teletype Mode. Functionally identical to the PC.

Function 15: Return Current VIDEO Mode. Functionally identical to the PC, except, of course, that it returns mode numbers in the range 0-10.

Function 16: Set Palette Registers. This is a new function not present in the "old" PC ROM BIOS. It allows direct control over the 16 palette registers and border color. Each register may be modified individually, or the entire group can be reset in one call by passing the address of a color value list, For more information on the various video driver functions, see ROM BIOS listings beginning on page A-29 of the IBM PC*jr* *Technical Reference* and on page A-46 of the IBM PC/XT *Technical Reference* version 2.02.

— Ray Duncan

BASIC supports the PCjr's enhanced sound capabilities with one new statement and additional options for three others.

video system from the default of 16K.

The new SCREEN graphics modes are

- 3: 160 by 200 in 16 colors
- 4: 320 by 200 in 4 colors with variable palette
- 5: 320 by 200 in 16 colors
- 6: 640 by 200 in 4 colors

All of the new models allow the user to change the actual color displayed by any of the 4 or 16 color values by using the PALETTE statement to set the correspondence for a single value/color pair or by using the PALETTE USING statement to set all 16 pairs from an integer array.

Mode 4 is similar to the old mode 1, but causes a different interpretation of the COLOR statement. In mode 1, COLOR specifies the background color and a choice of two palettes (red/green/brown or cyan/magenta/white); in mode 4, COLOR accepts independent foreground and background colors.

All of the existing graphics commands (LINE, CIRCLE, PAINT, etc.) work in all of the new modes.

BASIC supports the PC*jr*'s enhanced sound capabilities with one new statement and additional options for three others. A SOUND ON must be executed to enable the enhanced sound features. The new NOISE statement selects the source, volume, and duration of a noise burst. The source can vary in pitch and coarseness (pink noise is less coarse, white noise is more so.)

The SOUND statement has added options for volume and voice (one of three channels), which support the PC*jr*'s three-channel sound chip. The PLAY statement will accept up to three strings of music language commands (one for each voice), and the music language has added a notation for volume control.

The new TERM statement causes the interpreter to copy the embedded BASIC program from the cartridge into the workspace, then RUN it. The TERM program provides a simple way to set the communications parameters and emulates a dumb ASCII terminal. It's perfectly suitable for calling bulletin board systems and the like. You can use the break key to stop the program, then LIST, modify, and even SAVE it if you want to (it's not protected).

Sound System

The heart of the PC*jr*'s enhanced sound system is an audio multiplexer that selects one of four sources and connects it to the audio output section of the machine. The output is available at a standard RCA phono jack in the rear of the system unit and is also sent to a TV receiver through the RF modulator cable.

The four audio sources are

- Channel 2 of the 8253 timer (also used for the beeper)
- the audio cassette input
- the audio input signal from the I/O expansion connector
- the TI 76946 Complex Sound Generator chip

and their selection is controlled by bits 5 and 6 of output port &H61.

The speaker of the old PCs is replaced in the PC*jr* by a tiny piezoelectric beeper, which is connected only to the timer 2 output, gated by bit 1 of port &H61. This is compatible with the sound generation scheme in the original PC. The beeper is *not* connected to the output of the audio multiplexer, so none of the enhanced features can be heard without an external amplifier or TV.

The inclusion of an audio input in the expansion bus is tantalizing. Expect to see add-on speech synthesizers, and maybe even better quality music synthesizers, for the PC*jr*.

The multivoice sound chip in PC*jr* is the same one used in many home and arcade video games. It is capable of making toy-organ-quality three-part harmony (Baroque music seems to sound best), explosions, helicopter noises, and so on. Each channel has independent attenuation (volume control) in 15 levels (plus off), giving a range of 2 dB to 28 dB. The frequency range of each channel is about 110 Hz to 112,000 Hz. Even Krypto couldn't hear the high end, but it would occasionally be nice to have some lower tones.

Listing 1 shows the use of the SOUND statement in BASIC to generate simultaneous pairs of tones to simulate DTMF or Touch-Tone dialing sounds. This is intended as an illustration only; it is not recommended that you try to transmit these sounds over your telephone. Instead try considering it a code practice oscillator for fans of the *Touch Tone Song Book*.

Communications

The PC*jr* uses the 8250A serial communications controller chip, which is essentially the same as the 8250 used in the previous PCs. The serial port on the system board is at I/O address &H2F8 and uses interrupt level IRQ3, which is the same as is used for the alternate asynchronous adapter in the PC. The internal modem card is addressed as the primary asynchronous adapter at &H3F8 and IRQ4. If the modem card is installed, it appears as COM1 to BASIC and DOS, and the system board port is COM2. If there is no modem card, the system port is COM1.

BIOS will also establish the system board serial port as LPT1 if there is no parallel printer attachment installed, provided that Carrier Detect (CD) is tied to Request to Send (RTS) in the printer cable attached to the serial connector. The IBM Compact

Printer is so configured, so it will automatically appear as LPT1. To attach a serial printer using the Adapter Cable for Serial Devices and have it automatically show up as LPT1, a user will have to jumper RTS to CD (pin 4 to pin 8 in the standard 25-pin D connector). If a parallel printer adapter is installed, the DOS mode commands can be used to redirect printer output to the serial port.

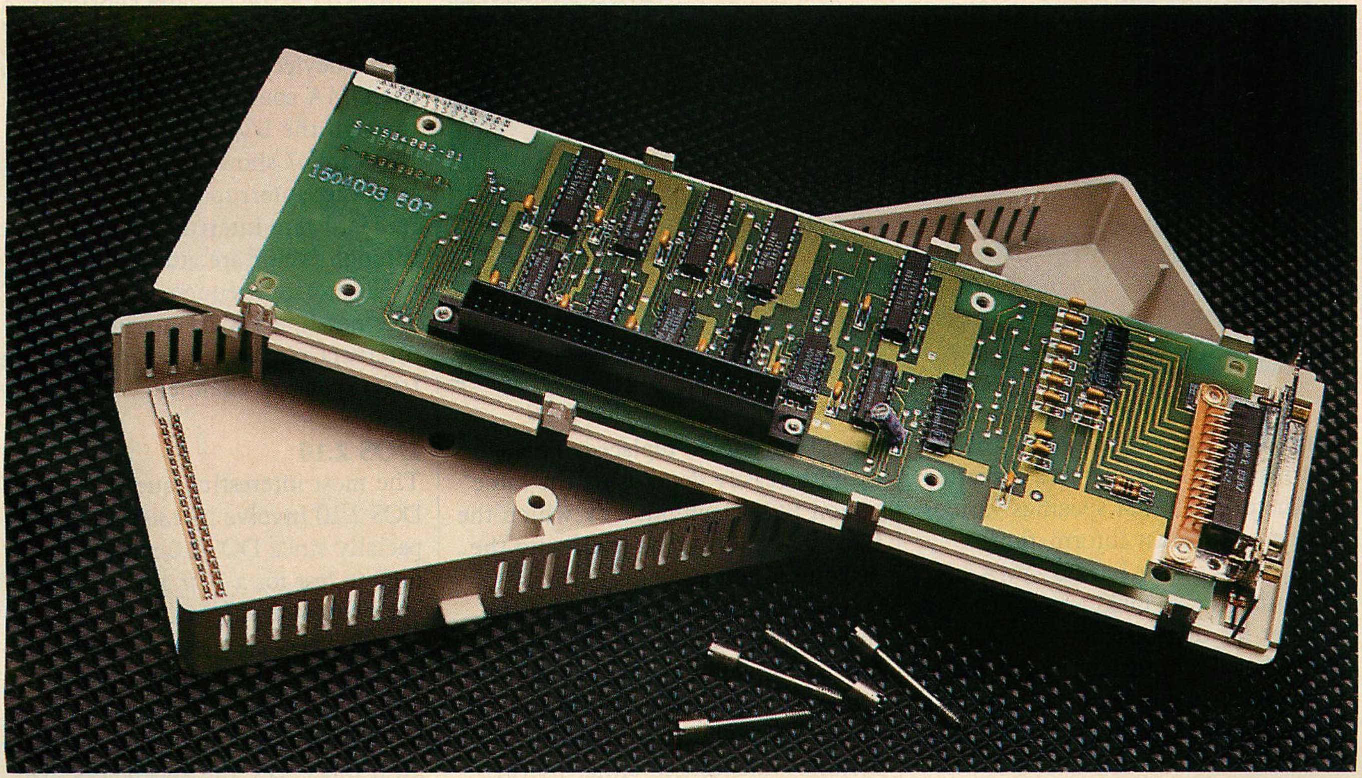
The serial hardware is similar to the PC version, but a different clock frequency is used to drive the baud rate generator. As long as BIOS is used to set baud rates, no difference is noticeable, except that BIOS will not set a rate of 9600 baud. The option for 9600 simply sets the rate to 4800 with no error notification. It may be possible to set the 8250A directly for 9600 baud, but the accumulated error due to the different clock frequency may prohibit reliable communication. In any event, for reasons discussed earlier, the PC*jr* has serious difficulty at rates higher than 1200 baud.

The PC*jr* Internal Modem operates at 110 or 300 baud, and has its own unique set of commands for controlling auto dialing, answering, transparency, and other functions. It is a direct-connect modem with some advanced features for waiting for secondary dial tones (useful if you have to dial 9 from your office for an outside line, for example). The command set is nothing like that for the popular Hayes Smartmodems, so any software you have that expects a Hayes-style interface will require some modification.

The Internal Modem is controlled by command strings that begin with a command character and end with a carriage return (see table 5). The command character defaults to control-N but may be changed with the NEW command. Command words can be typed as shown or as a single letter and are followed by their parameters, if any. Commands can occur anywhere in the data stream and are executed upon detection of the carriage return. Multiple commands can be sent after a single command character; commands are separated by a comma.

Diskette System

The diskette system in the PC*jr* uses the same NEC floppy disk controller chip as is used in the PC, but at different I/O addresses. The BIOS functions for diskette I/O, however, are



The PC-compatible parallel printer adapter contains a minimal amount of circuitry prompting us to wonder why the function was not included as a standard part of PCjr. Note the special screws used to bolt the option to the main chassis.

The I/O expansion bus is similar to that used in the PC, but the physical arrangement is different.

completely compatible. As in the PC, interrupt &H1E points to a diskette parameter table that specifies various timing and format information.

Since the PC*jr* has no DMA in the base system, BIOS ignores the parameter bit that instructs it to use DMA for disk transfers. It also forces a motor start-up delay of at least 500 milliseconds, disregarding smaller parameter values. If an external DMA device were added to the expansion bus, the diskette controller hardware could use it, but the BIOS routines would have to be replaced. This could be easily done using the same option ROM technique by which the fixed disk BIOS grafts itself onto the diskette functions.

Because of the provision for future DMA, the diskette controller can wait indefinitely for certain conditions to occur. A watchdog timer on the controller guards against indefinite waits caused either by this situation or by hardware failures. After a suitable interval, it then generates IRQ6.

I/O Addressing And Expansion

Table 6 shows the I/O address map for the PC*jr*. The major devices on the system board, with the exception of the diskette controller and some of the bits on the 8255, are addressed exactly as they were in the PC. In most cases, sticking to BIOS or higher-level interfaces will mask any differences among the PC family.

The I/O expansion bus is similar to that used in the PC, but the physical arrangement is different. Major functional differences include an additional audio input line, only three interrupt requests (the PC had five), and the inclusion of Hold Request and Hold Acknowledge signals to allow for external bus masters (DMA, other processors, etc.).

The bus also provides DRQ0 and DACK0 for the diskette controller to access an external DMA chip. Other DMA devices would have to access the DMA controller directly, not through the I/O channel.

Table 7 shows the processor and hardware interrupts for the PC family. Hardware interrupts &H08 through &H0F are attached to the 8259 interrupt requests 0 through 7. The notation IRQn indicates which interrupt requests are available in the I/O expansion channel.

DOS 2.10

The most interesting questions about DOS 2.10 involve its *raison d'etre*, especially since DOS 2.0 already knew how to test for a PC*jr* and how to invoke commands from cartridges.

The best guess is that IBM took this opportunity to clean up some minor bugs, spruce up the documentation, and raise the price for us technical folks. Yes, the appendices that explain how to make system calls and how to use the ANSI.SYS terminal driver, which used to be included

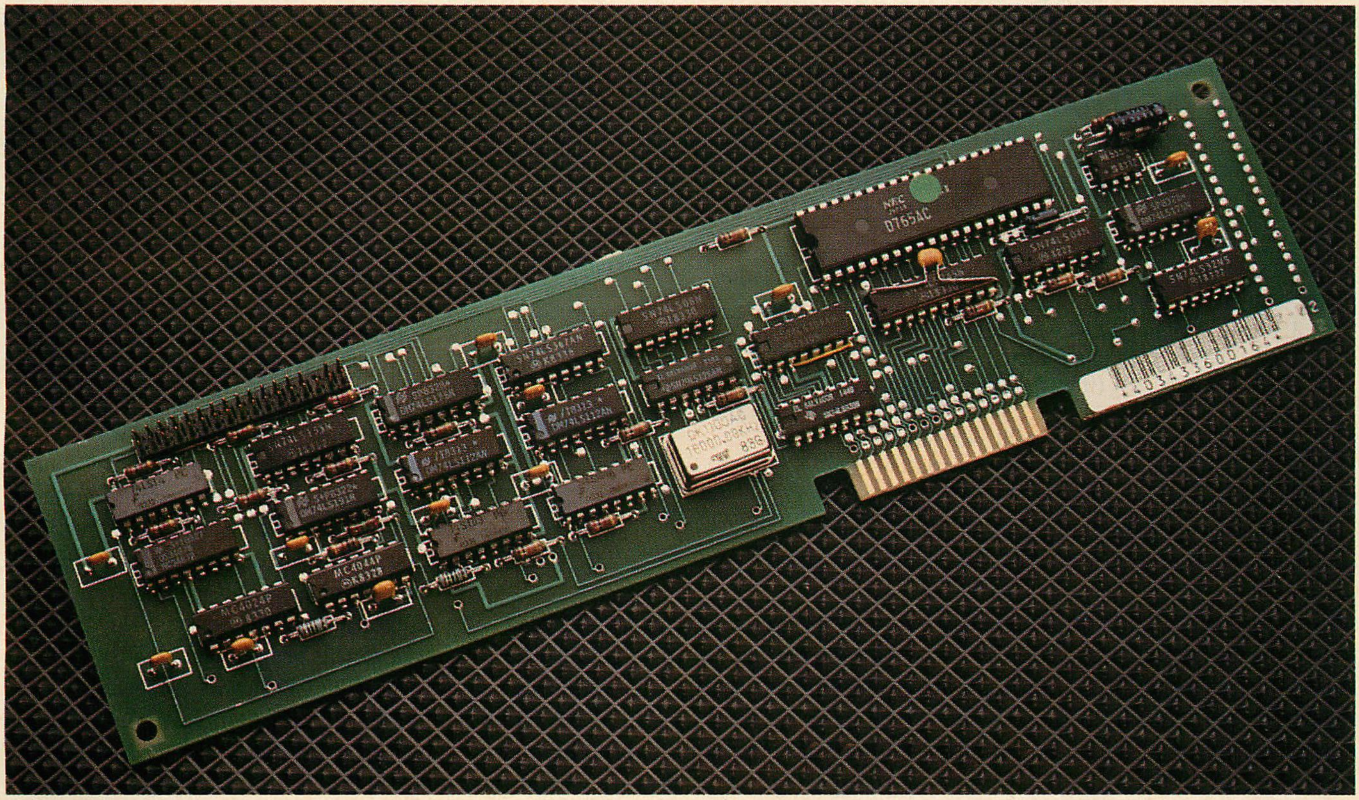
Table 5: PCjr Internal Modem Commands

Answer	Go offhook and enter answer mode
Break n	Send n x 100ms break signal
Count n	Count rings before answering incoming or aborting outgoing call
Dial m..m	Dial specified string
Format n	Specify parity, length, stop bits
Hangup	Disconnect and go onhook
Initialize	
Long Response o	Select verbose or terse responses
Modem	Force modem to data state
New p	Change command character to p
Originate	Go offhook and enter originate mode
Pickup	Go offhook and enter voice state
Query	Query modem status
Retry	Retry Dial command if busy every 40 seconds up to 10 times
Speed o	Select 110 or 300 baud
Transparent n..n	Ignore command sequences in next n..n bytes
Voice	Force modem to voice state
Wait	Take no action (including autoanswer) until next command
Xmit	Transmit DTMF tones in voice state
Ztest o	Perform hardware integrity or loop back test

for free, are now called the *DOS Technical Reference*, come in a separate binder, and cost $35.

For your nontechnical friends and relatives, DOS 2.1 includes the Disk Operating System User's Guide. A colorful introduction to the essentials of using DOS, it tells us that DOS "controls the movement of information on your computer," how to make backups (and why it's important), and offers brief guides to the fundamental commands (like DIR). Your guide is a cartoon chicken, who also appears in the new MUSICA.BAS demo program for the PC*jr*. Other books on junior are already proliferating, as you will see in the Book Review section in this issue starting on page 188.

Sometimes the User's Guide gets a little silly—for example, when it



Considerably more compact than its PC counterpart, the diskette controller resides in a dedicated slot in the PCjr chassis. It uses the same NEC controller chip as the PC.

Sometimes the User's Guide gets a little silly—for example, when it says that to see what's on a diskette, the user should first have the diskette (!), then type DIR, then look at the screen (!!).

Table 6: PCjr I/O Address Map

Address	Function
020-021	8259A Interrupt controller
020	Control register
021	Mask register (after initialization)
040-043	8253-5 Timer
040	Timer 0
041	Timer 1
042	Timer 2
043	Timer control
060-063	8255-5 Programmable peripheral interface
060	Keystroke storage for PC compatibility
061	Speaker, Alpha, Cassette, Sound control
062	Keyboard, Configuration, Cassette input
063	8255 Mode control
0A0	NMI Mask register
A0	NMI mask, IR test enable, timer 1 clk, HRQ disable
A0	(input) clears keyboard data latch
0C0	SN76496N Complex sound generator
0F0-0F7	Diskette interface
0F2	(output) Drive/motor select, watchdog control
0F4	(input) FDC Main status register
0F5	FDC Data register
201	Joystick interface
201	(input) digital input (buttons), resistive inputs
201	(output) start conversion of resistance to pulse
2F8-2FF	8250A Serial port
378-37B	Parallel Printer Adapter
378	Data latch
379	(input) Status
37A	Control latch
3D0-3DF	Video subsystem
3D4	6845 Address
3D5	6845 Data
3DA	(input) Video status
3DA	(output) Video Gate Array address then data
3DB	Clear light pen latch
3DC	Preset light pen latch
3DF	CRT/Processor Page register
3F8-3FF	Internal modem

Listing 1 DIAL.BAS

```
10 'File: DIAL.BAS
20 'Auth: Thomas V. Hoffmann  --  Feb 1984
30 'Edit: TVH  23-Feb-84  11:00pm
40 '
50 '   Use Multi-voice Sound Chip in PCjr
60 '          to Generate DTMF Tones
70 '
80 DIM TONE (12,2)
90 '
100 '-- Init Tone Frequency Data
110 DATA            941,1336            :'   0
120 DATA 697,1209, 697,1336, 697,1477 :' 1 2 3
130 DATA 770,1209, 770,1336, 770,1477 :' 4 5 6
140 DATA 852,1209, 852,1336, 852,1477 :' 7 8 9
150 DATA 941,1209,            941,1477 :' *   #
160 '
170 FOR I=0 TO 11
180   FOR T=1 TO 2
190     READ TONE(I,T)
200   NEXT T
210 NEXT I
220 SOUND ON
230 ONTIME = 18.2 * .2   '200 ms
240 OFFTIME= 18.2 * .08  ' 80 ms
250 '
260 '-- Get Input and Dial
270 INPUT NUMBER$
280 FOR I=1 TO LEN(NUMBER$)
290   D$=MID$(NUMBER$,I,1)
300   D=VAL(D$)
310   IF D$="*" THEN D=10
320   IF D$="#" THEN D=11
330 '
340   SOUND TONE(D,1),ONTIME,15,1
350   SOUND TONE(D,2),ONTIME,15,2
360 '
370   SOUND 32767,OFFTIME,,1
380   SOUND 32767,OFFTIME,,2
390 NEXT
400 IF LEN(NUMBER$) <> 0 THEN 230
410 END
```

says that to see what's on a diskette, the user should first have the diskette (!), then type DIR, then look at the screen (!!), on which he will see what files are on the diskette. If this were the IBM First Aid Kit User's Guide, the reader might be told to check if he's alive by following these steps: (1) get a newspaper, (2) read the obituaries, (3) if he gets to the end without seeing his name (see chapter 1, "Finding Out What Your Name Is"), he is probably alive, although (4) IBM makes no warranties, expressed or implied . . . .

Later, in the error message section, the reader is warned that "Non-DOS disk" means "the file allocation table contains invalid information." That's heavy news for someone who 16 pages earlier had to be told he had to have a diskette before he could read it. Oh well, documentation *is* the hard part of programming.

Among the minor improvements in DOS 2.1 is a change that means that the still-undocumented SHELL command in BASIC and BASICA no longer causes the interpreter to forget where the program is. A silly error in MODE.COM was corrected (it looked for the monochrome display buffer at &HB4000 instead of at &HB0000 where it really is, but the user wouldn't notice because the incomplete address decoding on the

Table 7: PC Family Processor and Hardware Interrupts

Interrupt Number	PCjr	PC1, PC/XT
Processor Interrupts (00-07)		
0	Divide by zero	Divide by zero
1	Single step	Single step
2	NMI Keyboard	NMI Parity error, 8087
3	Breakpoint	Breakpoint
4	Overflow	Overflow
5	BIOS Print screen	BIOS Print screen
6	(Reserved)	(Reserved)
7	(Reserved)	(Reserved)
Hardware Interrupts (08-0F)		
8	8253 Timer 0	8253 Timer 0
9	IRQ1 Keyboard	Keyboard
A	IRQ2 (Reserved)	IRQ2 (Reserved)
B	Serial port	IRQ3 Commo (secondary)
C	Internal modem	IRQ4 Commo (primary)
D	Vertical retrace	IRQ5 Fixed disk
E	Diskette (watchdog)	IRQ6 Diskette (FDC complete)
F	IRQ7 Parallel printer	IRQ7 Parallel printer

Processor and hardware interrupt usage is quite similar on PC*jr* and previous members of the PC family.

monochrome card allowed the memory to respond to either address).

Since no changes are documented, it's hard to know what happened to programs like FORMAT, though it is rumored that problems relating to handling the fixed disk have been corrected in a number of utilities. I don't have a fixed disk yet, so I have no way of knowing. Table 8 summarizes the differences between the programs supplied with DOS 2.0 and DOS 2.1.

CONCLUSION

The PC*jr* is clearly a direct descendant of the original PC, but it is hardly a clone. In fact, it's the first really different IBM PC (the new portable PC seems pretty vanilla). IBM has been careful to support compatibility where it is reasonable, but has not been afraid to make

Pascal for the Masses

There are many reasons why BASIC has emerged as the predominant programming language used by owners of personal computers, but one fact stands out: BASIC is *free.* Just about every small computer includes BASIC as a standard feature, and even in the case of PC*jr* (for which the full-featured BASIC has been "unbundled" and costs $75), we might well expect that few PC*jr*'s will be purchased without it.

BASIC is also easy to learn and use—especially for quick and dirty programs—is usually well-matched to the computer in terms of feature and function, and is similar from computer to computer. Nonetheless, many PC users will ultimately want a language that is not quite so difficult for large programs, that allows greater flexibility of system and hardware access and control, and that provides greater performance. Many languages meet these criteria, but most of them cost more than $200 ($300 to $500 is more common), which is quite expensive in comparison to the cost of PC*jr*.

That is why I was so delighted to find an extraordinary exception to the rule: Turbo Pascal, from Borland International. At $49.95, it is a complete Pascal language system that includes a full-screen editor and direct .COM file generator. That would be enough for the price, but it also compiles quickly (more quickly than any other Pascal compiler I know), generates very satisfactory code with very satisfactory performance (I estimate that it is about 30 percent slower than IBM Pascal, although it is faster for some benchmarks), and offers a number of nice extensions and features.

Two features are worth mentioning here. (Turbo Pascal is one of four compilers examined in *Tech Journal*'s forthcoming review of Pascal compilers). First, both compile-time and run-time errors are located in source code. The system traps the error and then switches to the editor with the cursor under the source line containing the error. For syntax errors, this is a nice BASIC-like facility usually found only in interpreted language systems. Second, the system includes a complete set of library routines for PC-DOS and BIOS access, memory access, and text screen control (clear screen, locate cursor, etc.). Many language systems do not include such fundamental routines, something I find irritating. Overall, the implementation seems to be quite professional.

I found Turbo Pascal to be everything the ad claimed and more. For $49.95, it is the bargain of the century.

And of course, it runs on the PC, XT, and PC*jr*.

—Will Fastie

Turbo Pascal
$49.95
Borland International
4807 Scotts Valley Drive
Scotts Valley, CA 95066
(requires 128KB RAM, 1 disk drive, DOS)
CIRCLE 493 ON READER SERVICE CARD

Most of the problems and limitations of PCjr can be overcome; in many cases the exact mechanism is clear, it's just that no one has done it yet.

Table 8: DOS 2.10/2.00 Program Comparison

Program Name		2.10 Size	2.00 Size	Functional Difference
COMMAND	COM	17792	17664	Version + Undocumented
ANSI	SYS	1664	1664	None
FORMAT	COM	6912	6016	???
CHKDSK	COM	6400	6400	DOS version check
SYS	COM	1680	1408	???
DISKCOPY	COM	2576	2444	???
DISKCOMP	COM	2188	2074	???
COMP	COM	2534	2523	???
EDLIN	COM	4608	4608	None
MODE	COM	3139	3139	Corrects check for mono display
FDISK	COM	6369	6177	???
BACKUP	COM	3687	3687	None
RESTORE	COM	4003	4003	None
PRINT	COM	4608	4608	DOS version check
RECOVER	COM	2304	2304	None
ASSIGN	COM	896	896	None
TREE	COM	1513	1513	None
GRAPHICS	COM	789	1280	None
SORT	EXE	1408	1280	???
FIND	EXE	5888	5888	None
MORE	COM	384	384	None
BASIC	COM	16256	16256	Version + Undocumented
BASICA	COM	26112	25984	Version + Undocumented
EXE2BIN	EXE	1664	1664	None
LINK	EXE	39936	39936	Version + Undocumented
DEBUG	COM	11904	11904	None
SAMPLES	BAS	3067	2304	Version + PCjr check
ART	BAS	1920	1920	None
MUSIC	BAS	10291	8704	???
MUSICA	BAS	15072	---	Uses PCjr graphics
MORTGAGE	BAS	6272	6272	None
COLORBAR	BAS	1536	1536	None
DONKEY	BAS	3584	3584	None
CIRCLE	BAS	1664	1664	None
PIECHART	BAS	2304	2304	None
SPACE	BAS	1920	1920	None
BALL	BAS	2048	2048	None
COMM	BAS	4352	4352	None

None = programs are identical
DOS version check = program checks for DOS version 2.10 or 2.00
??? = functional difference unknown

changes where warranted.

Most of the problems and limitations of PCjr can be overcome; in many cases the exact mechanism is clear, it's just that no one has done it yet. At some point, the expense of upgrading the PCjr as far as it can be upgraded will stop making economic sense compared to other alternatives, but that's okay. When that happens there will be plenty of other interesting things to look at, from IBM and from the rest of the world.

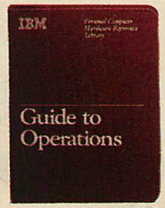
PCjr Documentation

From the outside, the documentation for the PCjr appears quite similar to that for the Personal Computer, but inside the familiar binders are manuals that sometimes differ radically. In a concentrated effort to make the novice feel comfortable with his computer, IBM has used the cartoon characters of a dog, cat, bird, and a boy named P.C. to guide the beginner through his first experiences with the computer. The *Guide to Operations* comforts the reader with the words, "It's Easy! We'll Take You Step By Step. . . . "

Although this may console the computer neophyte, experienced users may find these characters distracting and will soon discover that they have to wade through mounds of introductory material to find the details that most interest them.

Guide to Operations

(Included with system unit)
Novice to expert



Experienced users will be happy to learn that chapter 2 in this guide may be skipped entirely. In this chapter, little P.C. guides the beginner through a "Keyboard Adventure," an interactive tutor invoked by pressing the Escape key from ROM BASIC immediately after a system reset. The keyboard is explained more completely in chapter 3, again with the aid of little P.C. and his friends. Chapter 4, "Choosing Keys," should be of great interest. A Keyboard Difference Chart lists the key combinations for the PC keyboard and the equivalent keystrokes on the PCjr. Programs with instructions for use on the PC can be run on the PCjr by making the appropriate keystroke translations. For example, Crtl/PrtSc on the PC translates to Fn/Echo on the PCjr.

As in the *Guide to Operations* for the PC, installation instructions for optional equipment are supplied separately and are added to the binder as the options are installed. The PCjr diskette drive installation and operating instructions are easy to understand and the illustrations are superb.

In the PCjr, hardware diagnostics are programmed into ROM, rather than being supplied on a separate diskette; they can be invoked by pressing and holding the Ctrl, Alt, and Ins keys. The

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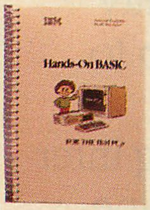
In Washington State, call 206-828-8088. Ask for operator C5, who will rush you your order, send you more information, or give you the name of your nearest dealer to see Microsoft Pascal in action.

*Price exclusive of handling and Washington State sales tax.

documentation on these diagnostics is so well done that it is easy to determine if service is required, even if the user knows little about the computer. A bonus feature of these diagnostics is that they can be used to calibrate the joysticks.

"Introduction to the PC*jr*," which is supplied on diskette with the *Guide to Operations*, introduces the keyboard, elementary DOS and BASIC commands, and printer operations. This interactive tutor is the same as the "Introduction to the PC" that is supplied with the PC, but that it has been customized for the PC*jr*.

Your IBM PCjr Sampler
(Included with the system unit)
Novice to expert

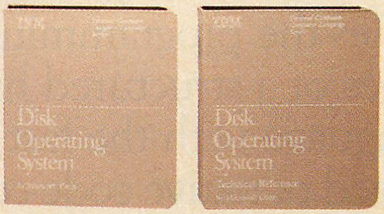


As its name implies, this diskette contains a sampling of programs that demonstrate the capabilities of the IBM PC*jr*. Obviously aimed at the home user, the programs consist of several games and some household management tools, such as a checkbook handler, shopping list generator, recipe file, and monthly expense spreadsheet. To run the sampler, the PC*jr* must have 128K of memory and a diskette drive. The Telephone Connector program, which can be used to communicate with other computers, requires the internal modem. All of these programs present a simple and consistent human interface and are self-documented. Since the source code is not supplied, this diskette is really a sampler of what the PC*jr* can do, not an example of how to implement the functions.

Hands-On BASIC for the IBM PCjr
(Included with the system unit)
Novice
For readers with no programming experience, IBM offers *Hands-On BASIC*, an introduction to both programming and PC*jr* Cartridge BASIC. The purpose of this book is to make the novice feel in control of the computer. To ensure that this goal was met, IBM had people use and evaluate the book as it was written.

The result is an inviting, spiral-bound self-tutor meant to be read at the keyboard. Hands-on exercises teach common BASIC commands as well as the sound and graphics features of the PC*jr*. Questions are asked after each session, with answers in the back of the book.

DOS 2.10
(Includes *Disk Operating System User's Guide*, standard reference manual, and operating system—$65.00)
Novice to expert
DOS 2.10 Technical Reference
($30.00)
Expert



Unlike the documentation for DOS 2.00, all of which is included in one binder with the operating system, the

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DOS 2.10 documentation is divided into three parts: one booklet (*Disk Operating System User's Guide*) and two manuals (the standard reference manual and the *Technical Reference*). The *User's Guide* and the standard reference manual are provided with the operating system; the *Technical Reference* must be purchased separately. Despite this reorganization, the information provided is essentially the same.

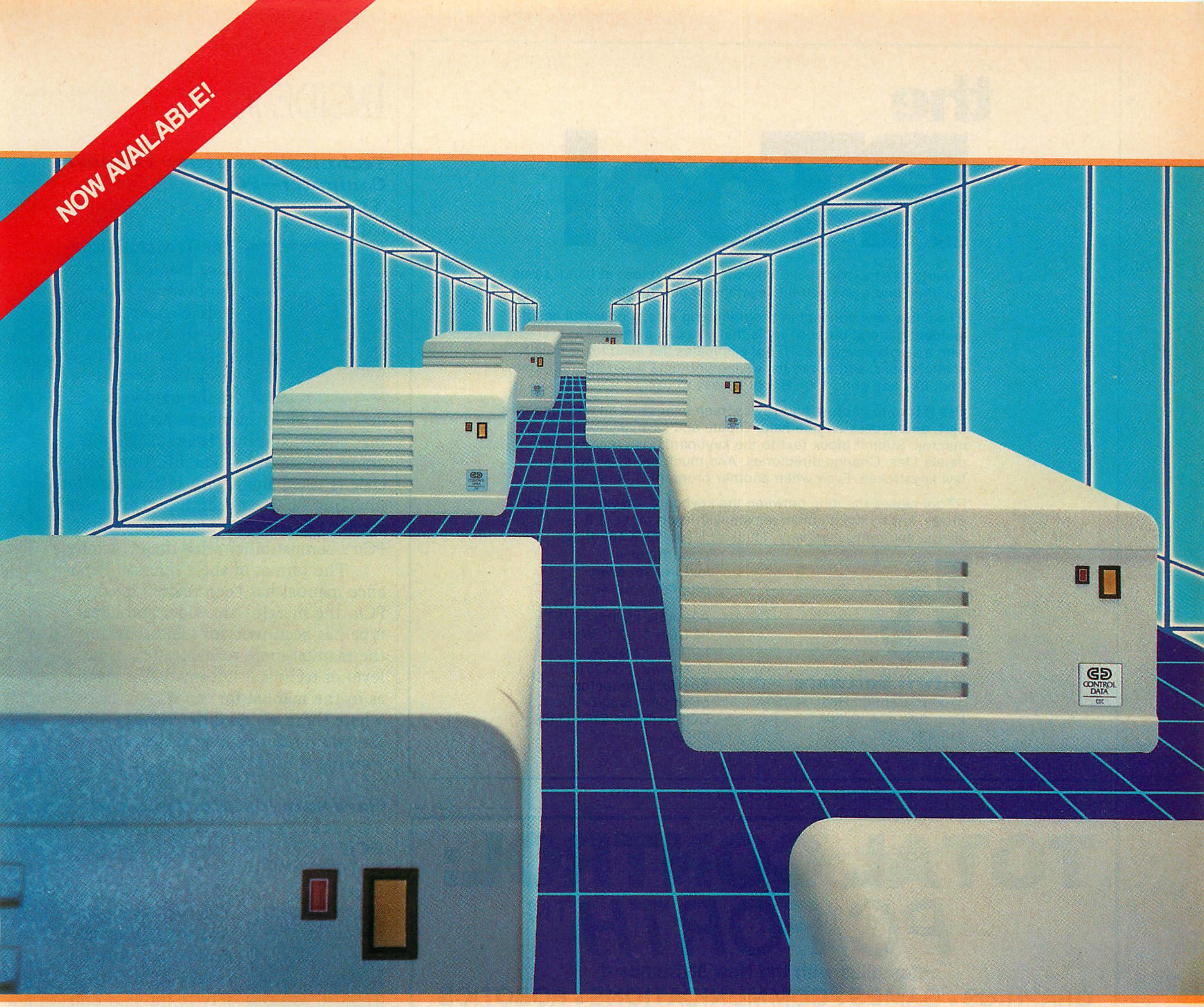
The *User's Guide* is intended to get the new user started using DOS. It contains instructions on caring for diskettes, naming and referencing files, copying files and disks, and formatting disks. With the standard reference manual, the *User's Guide* provides all the information the average user needs.

The *Technical Reference* is intended for experienced programmers. It describes DOS memory and disk allocation schemes, DOS function calls, device driver installation, and extended screen and keyboard control. This information was printed in chapters 13, 14, and appendices B-H of the DOS 2.00 manual.

Missing from the DOS 2.10 manual collection are the update pages for BASIC 1.1 that came automatically with DOS 2.0. In place of these pages, the buyer is issued a certificate that can be redeemed for the BASIC 1.1 update at no charge. Although this is not a problem for PC*jr* owners, PC owners who upgrade from DOS 1.1 directly to DOS 2.10 will need to send for this update, which describes using the 2.00 enhancements in BASIC.

BASIC: Personal Computer—PCjr
($75.00)
Average user to expert
The BASIC cartridge and its reference manual are not included with the PC*jr*, but must be purchased separately. Only Cartridge BASIC supports the added graphics and sound capabilities of the PC*jr*, as well as the new terminal emulation mode. In fact, the PC*jr* complains that a cartridge is needed if the user attempts to run BASIC or BASICA from the DOS 2.10 diskette.

Descriptions of the new BASIC commands for the PC*jr* and, of course, the cartridge containing BASIC, are included in the Cartridge BASIC manual; otherwise, the manual is essentially the same as the original BASIC documentation for the PC. The new manual is a reference for both the cartridge and the cassette versions of PC*jr* BASIC; it assumes that the user has some programming knowledge.



StorageMaster™ Fixed Disk builds stronger PCs three ways.

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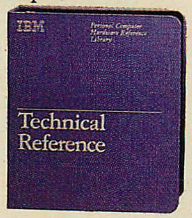
*This capability requires the use of a StorageMaster 301 Controller.

CIRCLE NO. 131 ON READER SERVICE CARD

CONTROL DATA

INSIDE *jr*

Technical Reference: Personal Computer—PCjr
($35.00)
Expert



The *Technical Reference* manual is the hardware and software engineer's Bible; all Truth is contained within. The design and operation of the hardware is described, with specifications for timing, power, and interfacing. Logic diagrams are supplied. The BIOS source code is listed along with instructions for invoking BIOS services. Especially interesting is section 4, which covers the PC*jr*'s compatibility with the PC family.

The format of the *Technical Reference* manual has been revised for the PC*jr*; the margins are wider and larger type has been used for tables, making the manual more readable. The same level of technical information is given as in the manual for the PC—in fact, where there are no differences between the two machines, almost the same wording is used.

Hardware Maintenance and Service: Personal Computer—PCjr
($88.00)
Expert

The *Hardware Maintenance and Service* manual is a must for anyone who plans to service the PC*jr* himself. Detailed instructions are given, in flowchart fashion, for running the advanced power-on self test (POST) and the advanced tests in order to isolate a hardware problem. After the problem is diagnosed, the proper repair procedure is outlined. A complete parts catalog is provided to aid in the repair work. Unlike the comparable volume for the PC, this manual provides no diagnostic diskette, as all such programs are included with the PC*jr*.

—Julie Anderson

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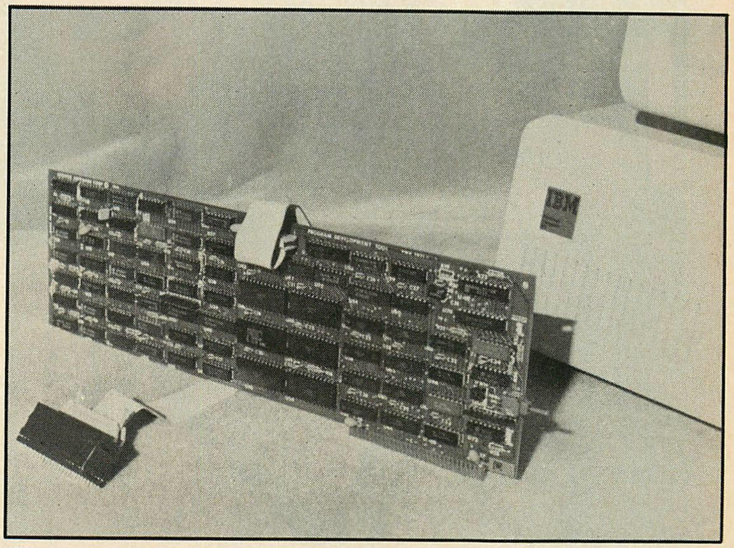
PROGRAM DEVELOPMENT TOOL (PDT-PC)



for IBM-PC* and Compatibles

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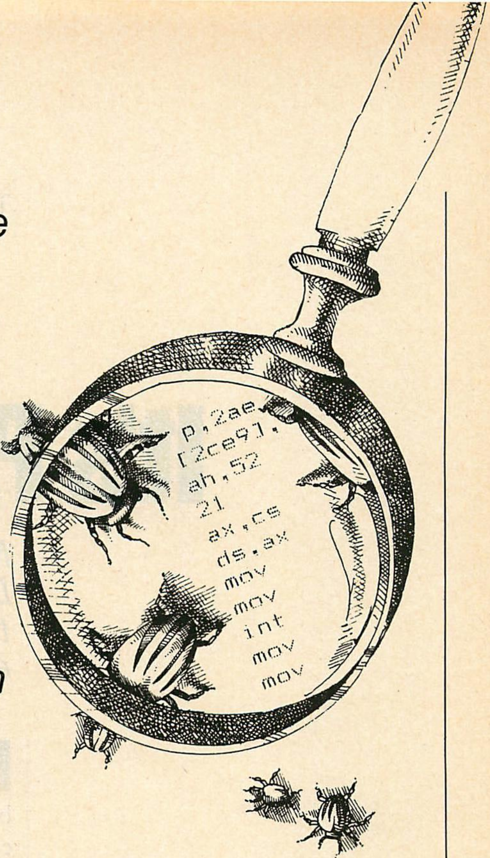
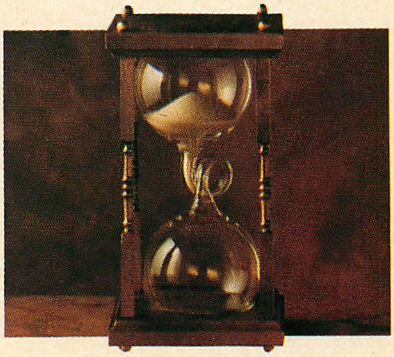


Brick walls are not unfamiliar *to even the best software developers. Their systems are often sophisticated and complex, and it's difficult to engineer a system perfectly. Anomalies arise, perhaps the result of a design flaw, but perhaps not. Maybe a part of the PC is misunderstood. New machines mean new questions: Is IBM's Portable PC the same as the regular PC? Is the XT the same as the PC?*

Debugging tools help software developers climb those brick walls, get to that perfect system. On the following pages are reviews of the current generation of those tools—hardware and software—some ways around a small problem in DEBUG, and an elegant way to debug BASIC programs. Here's the line-up.



THOMAS V. HOFFMANN

It's PC Probe!

More powerful than DEBUG, less expensive than an in-circuit emulator

I shall try to correct *errors where shown to be errors, and I shall adopt new views as fast as they shall appear to be true views.*
—Abraham Lincoln

Remember *that time is money.*
—Benjamin Franklin

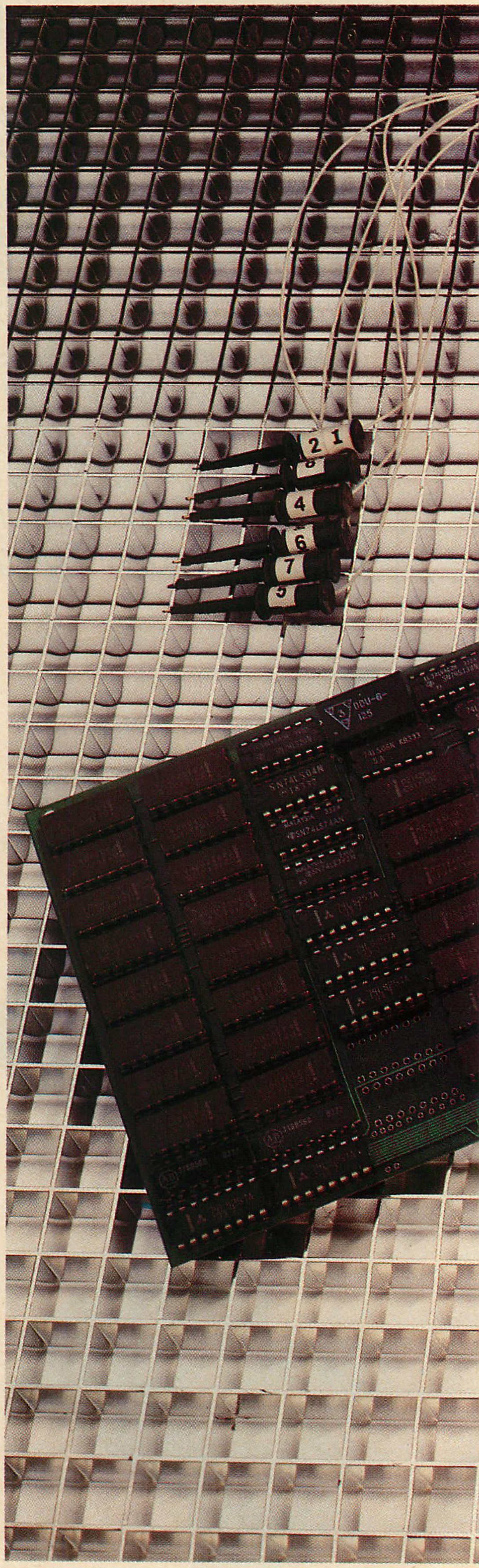
If you've got the money, *honey, I've got the time.*
—Lefty Frizzel

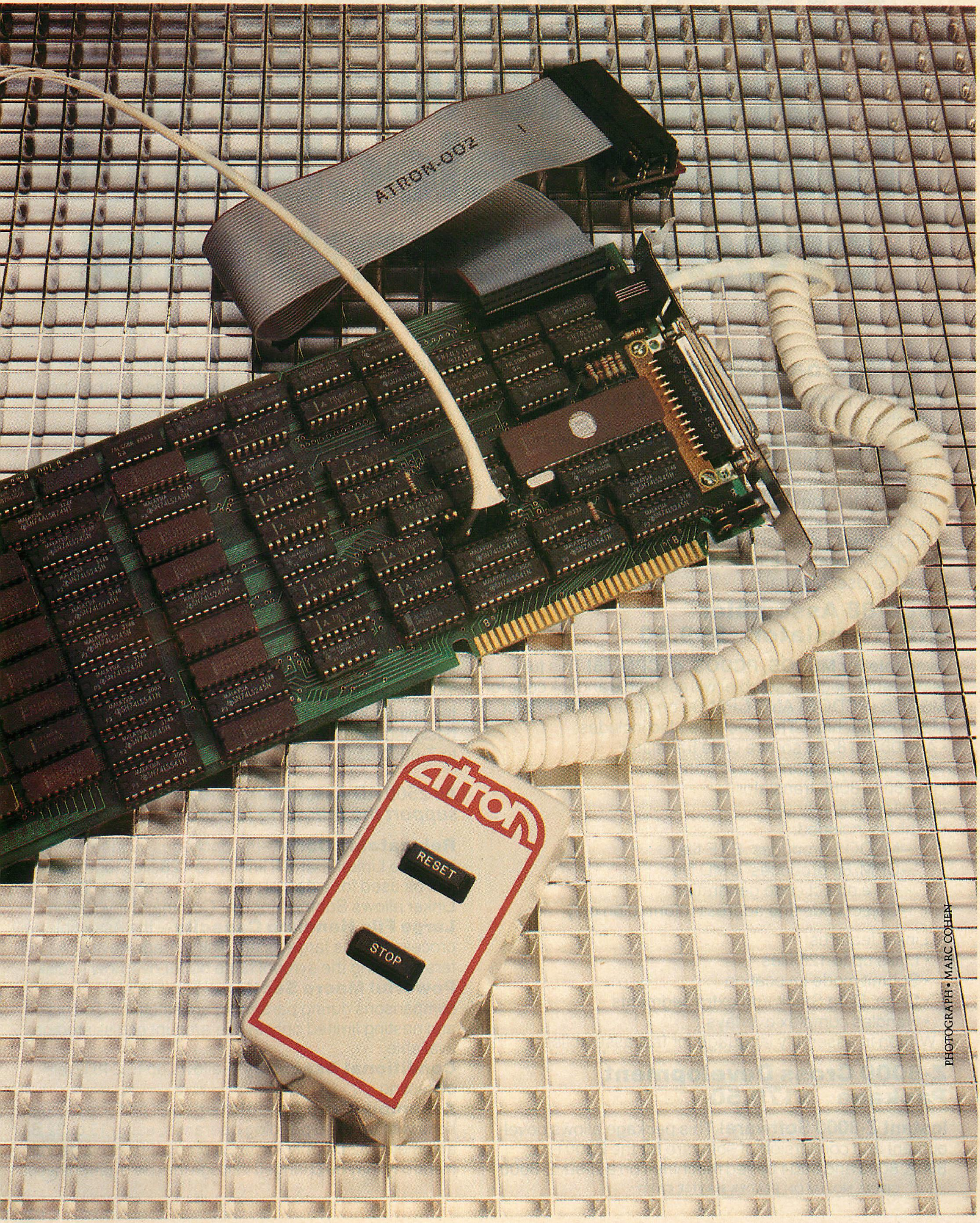
Most people wouldn't guess that our sixteenth president harbored a latent talent for debugging computer systems or that statesmen and country singers understand the economics of software testing. They'd probably figure Honest Abe was writing about slavery, the Civil War, or some other issue of his day. But that's most people. Most people don't read this magazine either.

To me it's plain that Lincoln's resolution is also an excellent prescription for software maintenance and repair: identify the errors, investigate the causes, believe what the evidence shows, correct the errors. This is not unlike the scientific method (Franklin was a scientist, too, remember), in which a scientist develops a theory to explain observed events, hypothesizes a new result, conducts experiments to test the hypothesis, and modifies the theory.

Telling people to use this method is good advice, but it's not always easy for them to follow it. The hardest part, of course, is thinking clearly and logically, without jumping to unwarranted conclusions, but with an occasional burst of intuitive insight grounded in a deep understanding of the program. Atron's PC Probe can help software developers think clearly and logically. It won't

Thomas Hoffmann is a contributing editor to this magazine.





PHOTOGRAPH • MARC COHEN

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- COM to Hex Converter (to convert your object files to Hex for PROM creation, etc.)
- 52 page User Manual

8086/88 Assembler with Translator $99.50

Available for MSDOS, PCDOS, or CPM/86! This fully relocatable macroassembler will assemble and link code for MSDOS (PCDOS) AND CPM/86 on either a CPM/86 or MSDOS machine. This package also includes:
- An 8080 to 8086 source code translator (no limit on program size to translate)
- A Z-80 to 8086 translator
- 64 page user manual
- 4 linkers included:
  - –MSDOS produces .EXE file
  - –CPM/86 produces .CMD file
  - –Pure object code generation
  - –Object code and address information only

  Linker features:
  - Links up to 128 files
  - Submit mode invocation
  - Code, Data Stack and extra segments
  - Handles complex overlays
- Written in assembly language for fast assemblies.

Z-8000 Cross Development Package $179.50

Instant Z-8000 Software! This package allows development and conversion of software for the Z8001, 8002, 8003 and 8004 based machines on a Z-80, Z-8000 or 8086 machine. This powerful package includes:
- a Z-80 to Z-8000 Assembly Language Source Code Translator
- an 8080 to Z-8000 Source Code Translator
- Z-8000 Macro Cross Assembler
- Linker and Loader
- COM to Hex File Converter
- a 100 page User Manual
- a Zilog Z-8000 Technical Reference Manual

The Translators provide Z-8000 source code from Intel 8080 or Zilog Z-80 source code. This source code expansion is from 2% to 11%. The Translator outputs a worksheet and a Z-8000 source file. The worksheets show each line of 8080 Z-80 code, with notes to help the programmer to optimize performance, and further lower code expansion. It even comments lines it adds! The Z-8000 source code used by these packages are the unique 2500AD syntax using Zilog mnemonics, designed to make the transition from Z-80 code writing to Z-8000 easy.

All 2500 AD Assemblers and Cross Assemblers support the following features:

Relocatable Code—the packages include a versatile Linker that will link up to 128 files together, or just be used for external reference resolution. The Linker allows Submit Mode or Command Invocation.
Large File Handling Capacity—the Assembler will process files as large as the disk storage device. All buffers including the symbol table buffer overflow to disk.
Powerful Macro Section—handles string comparisons during parameter substitutions. Recursion and nesting limited only by the amount of disk storage available.
Conditional Assembly—allows up to 248 levels of nesting.
Assembly Time Calculator—will perform calculations with up to 16 pending operands, using 16 or 32 Bit arithmetic (32 Bit only for 16 Bit products). The algebraic hierarchy may be changed through the use of parentheses.

Include files supported—

Listing Control—allows listing of sections on the program with convenient assembly error detection overrides, along with assembly run time commands that may be used to dynamically change the listing mode during assembly.

Hex File Converter, included—for those who have special requirements, and need to generate object code in this format.

Plain English Error Messages—

System requirements for all programs: Z-80 CP/M 2.2 System with 64K RAM and at least a 96 column printer is recommended. Or 8086/88 96K CP/M or MSDOS (PCDOS).

Cross Assembler Special Features

Z-8—256 User defined registers names, directive to engage UPC, Z-80 style syntax.

8748—fully Intel source code compatible.

8051—256 User defined register names, bit addressable naming allowed.

6800 Family—absolute or relocatable modes, all addressing modes supported, Motorola syntax compatible.

6502—Standard syntax or Z-80 type syntax supported, all addressing modes supported.

8086 and Z-8000 XASM includes Source Code Translators

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8086/88 ASM			$99.50	$99.50	
8086/88 XASM	$179.50	$750.00			$179.50
Z-8000™ ASM		750.00			299.00
Z-8000 XASM	179.50		179.50	179.50	
Z-80 ASM	49.50				
Z-80 XASM		500.00	$99.50	$99.50	$99.50
Z-8 XASM	99.50	500.00	$99.50	$99.50	$99.50
6502 XASM	99.50	500.00	$99.50	$99.50	$99.50
6800,2,8 XASM	99.50	500.00	$99.50	$99.50	$99.50
6801,03 XASM	99.50	500.00	$99.50	$99.50	$99.50
6805 XASM	99.50	500.00	$99.50	$99.50	$99.50
6809 XASM	99.50	500.00	$99.50	$99.50	$99.50
8748 XASM	99.50	500.00	$99.50	$99.50	$99.50
8051 XASM	99.50	500.00	$99.50	$99.50	$99.50
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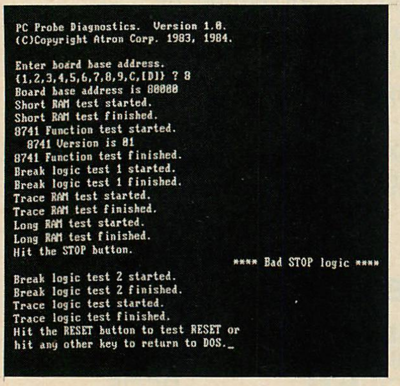


Photo 1:

Output from the PC Probe diagnostic program. The stop logic was not bad; we simply refrained from hitting the button as a test.

The manual is about 100 pages long

and comes in the standard IBM 3-ring binder with a software diskette in the back. In addition to the operating software and utilities, a diagnostic program is included to check the correct operation of the probe hardware. This is a nice touch.

bestow understanding, but it is a powerful tool for research.

HIGH-PRICED SPREAD

All debugging systems provide the same basic facilities: ways to examine and change the program state (memory and registers) and some means of initiating and controlling program execution. Traditional software debuggers like DEBUG, which is supplied with PC-DOS, are simply programs that reside in the same memory space as the program under test and share the same processor for execution. The simple ones have few options for examining and modifying memory (no assembly or disassembly, all numbers in hexadecimal). Fancier ones have more display modes, more breakpoints, assembly and disassembly facilities, and better human engineering. Simple software debuggers are relatively inexpensive: DEBUG is included with a $60 operating system.

At the other end of the spectrum are the in-circuit emulators, complex combinations of hardware and software that allow one computer to control and observe the operation of another, down to the most elemental details. Besides the simple execution breakpoint (stop when the program gets to location *X*), these systems allow breaking on various real-time bus events (stop when location *X* is read as data). Software debuggers generally can't detect such low-level events directly in real time, and the overhead in program size and execution speed makes software emulation infeasible. In-circuit systems from Intel for the 8088 start at about $7,000, not including the host computer system, which may be another $15,000 or more.

PC Probe offers the best of both worlds. The $2,495 system offers powerful hardware trace and breakpoint capabilities that are impressively close to those of a full-blown independent in-circuit emulator, as well as an excellent debug program complete with facilities for symbolic debugging of high-level language programs, all at a very reasonable cost.

WHAT'S IN THE PACKAGE

The heart of the PC Probe is a single printed circuit card that goes in one of the option slots in the PC. A 40-pin plug attached to the card by a flat cable is inserted in the processor socket on the PC motherboard, and the 8088 processor plugs into a socket on the probe plug. This allows the logic on the card to directly monitor signals at the CPU chip as well as on the expansion bus.

An L-shaped extraction tool is provided for removing the processor, which is quite a difficult operation since only one end is accessible, the other being blocked by the cassette and keyboard connectors. A plunger-type chip extractor that grabs both ends would be much better, especially if the unit will be installed and removed frequently (not really a very good idea in any case).

The printed circuit card has three connectors on the rear panel. An RJ-11 modular phone jack is used to attach an external button box (supplied), which has two buttons labeled *reset* and *stop*. The reset button performs a hardware reset to the PC, handy for those times when a program is out of control and the interrupts are off (so CTRL-ALT-DEL doesn't work). The stop button forces an unconditional breakpoint.

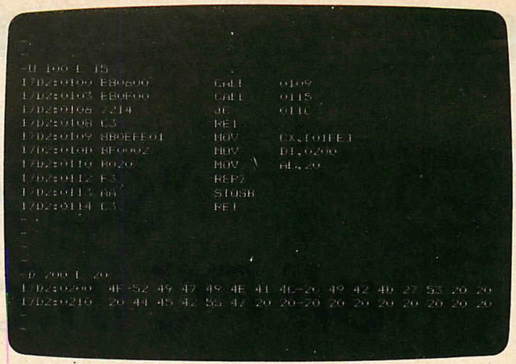
A 25-pin D connector is provided for attaching an external terminal (or another PC operating as a terminal). Using an external console facilitates certain kinds of breakpoints, such as on DMA accesses or interrupt routines used by DOS.

The third connector is thoughtfully provided for attaching an external power supply, for those cases in which a heavily loaded system can't handle the additional requirements of the Probe board.

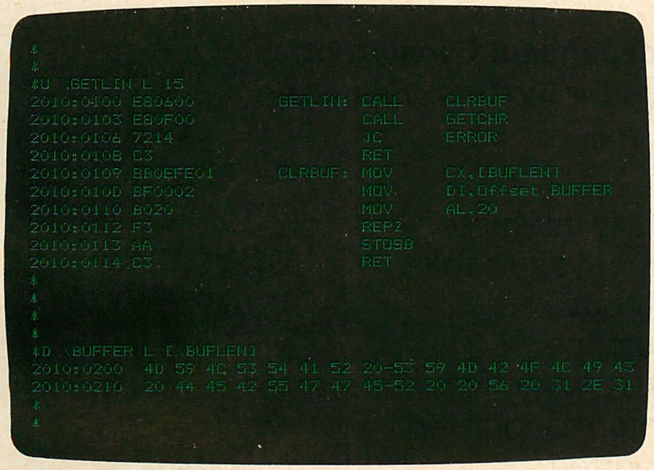
The *Installation and Users Manual* completes the package. It is about 100 pages long and comes in the standard IBM 3-ring binder with a software diskette in the back. In addition to the operating software and utilities, a diagnostic program is included

SCREEN PHOTOS • BLAKESLEE-LANE, INC.

The difference



Original IBM Debug Program



Mylstar Symbolic Debugger V1.1

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The plain and simple difference is that Mylstar's Symbolic Debugging Program speaks to your IBM PC in a language you both can understand, plain and simple.

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It's the enhancement to the *IBM Debug Program* you've been looking for—because it fills in the gaps—shortening the frustrating debugging process by as much as 50%—leaving you more time to do the work you need to do and the work you want to do, plain and simple.

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to check the correct operation of the probe hardware. This is a nice touch.

The manual is generally well written, though there are some rough spots and more than a few typographical errors. The command reference section is quite complete and easy to use. Both the manual and the software are still being improved. A 90-day warranty on the hardware, free software updates for one year, and four hours of technical support (presumably by telephone) are included in the price.

PRINCIPLES OF OPERATION

The PC Probe card contains a high-speed RAM trace buffer that can store complete information about the previous 1,024 bus cycles. The trace buffer records DMA, I/O, and memory accesses—with full 20-bit addresses and 8-bits of data—plus five other signals (either interrupt requests 2 through 6 or five external logic signals connected through an optional $100 logic probe cable).

Hardware breakpoint logic on the card detects the fancy hardware conditions beyond the powers and abilities of mortal software debuggers. There are three independent hardware breakpoints.

An additional 128K of RAM memory appears in the 8088 address space at any jumper-selectable 128K boundary. The debugger software is loaded here, then write-protected. This guards against the possibility that a runaway program might damage the debugger software; it also leaves nearly all of the ordinary user memory available to the operating system and user software. The debugger software handles memory examination and simple execution breakpoints directly, much like an ordinary software-only debugger would. In addition, this software controls the starting and stopping of hardware trace collection and sets up the hardware breakpoint logic.

An Intel 8741 microcontroller on the card operates the remote console. When the remote console is used, the system makes no use of the PC keyboard and display, leaving them for the exclusive use of the user program. The external console also permits greater flexibility in setting hardware breakpoints, both in interrupt routines and on certain hardware conditions.

BREAKPOINTS

Breakpoints allow the user to execute the program under test until specified conditions occur. The simplest form of breakpoint is the execution breakpoint, which stops execution immediately before a particular instruction is about to be executed and passes control to the debugger software. The PC Probe system provides up to five execution breakpoints and three hardware breakpoints. The hardware breakpoints stop execution when a particular address, which could be in either memory or I/O space, is accessed in a specified way. A second form of hardware breakpoint stops execution when one of several hardware signals is either high or low.

Breakpoint conditions are specified in the following format:

[I/O] address [verb] [DATA datavalue]

If I/O is present, the address is interpreted as an I/O port address; otherwise the address is a memory address. Addresses are specified in hexadecimal. Using the letter *X* in any digit position indicates a "don't care" condition for that part of the address, allowing breakpoints on a range of memory. For example, 004XX would include all addresses from 00400 to 004FF. The software version we tested only handles *X* in hex numbers; binary numbers with don't cares will be added in the near future.

The verbs below qualify the type of access on which to break:

R for read (memory) or input (I/O)
W for write (memory) or output (I/O)
A for any of read, write, or execute
D1 for DMA access (in or out) on DMA channel 1

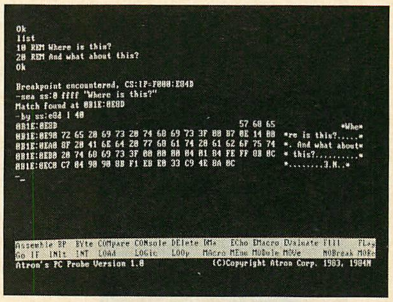


Photo 2:
PC Probe in action. The break point was induced by hitting the STOP button. Note the command menu at the bottom of the screen.

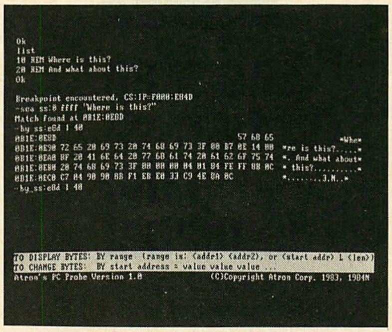


Photo 3:
PC Probe software can recall the last instruction (the cursor is just after "bv" with the rest of command restored). Note that the menu at the bottom has been replaced by command-specific information.

D2 for DMA access (in or out) on DMA channel 2

D3 for DMA access (in or out) on DMA channel 3

If no verb is specified, the break will be on instruction execution only.

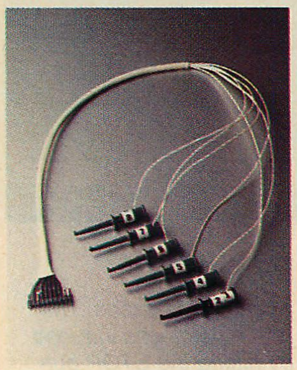
The key word DATA may be used to further qualify the breakpoint by requiring that the data read or written must match a certain byte value, which can also use the *X* convention for don't care.

The Probe debugger uses the G (GO) command to begin execution and to specify *non-sticky* breakpoints, just as the DOS DEBUG program does. These breakpoint are called non-sticky because they don't stick—they must be respecified each time a G command is given. Probe also has *sticky* breakpoints, set with the BP command:

BP number = breakpoint condition

These breakpoints remain in effect until they are deleted with the DElete BP command. It is a real convenience not to have to reenter multiple break conditions every time execution is resumed.

The stop button on the external stop/reset box can be used to return to the debugger on any human-detectable condition, sort of a bionic breakpoint. This is handy for regaining control of perverse programs that are executing where no breaks were set. Bionic breaks are also great for probing interactive programs and for use when the precise conditions don't matter or can't be predicted. For example, to find out where BASIC puts program text as it is entered a programmer could enter a statement, break, then search memory for the characters he just typed. (Photo 1 shows an example of this technique.)



The logic probe cable, an additional $100, *allows the probe to monitor the state of as many as five logic signals.*

The stop button on the external *stop/reset box can be used to return to the debugger on any human-detectable condition, sort of a bionic breakpoint. This is handy for regaining control of perverse programs executing where no breaks were set.*

Why Probe is So Much Better Than Debug

With a software debugger, such as DEBUG in PC-DOS, breakpoints are limited to simple execution breaks and can be placed only on locations in read/write memory. Although it is possible to single-step through ROM, this is tedious and impractical.

The PC Probe system offers several significant improvements. First, the hardware breakpoints can be set anywhere, including on ROM locations (using the A option). Second, the trace buffer provides a detailed backward look at the world *before* the break occurred, so the programmer can tell how the program got there and what happened along the way. Third, the don't-care, read/write, IO/memory, DMA, and data-value qualifications allow far greater precision (or laxity) in specifying the break condition, so no time is wasted trying to locate the situation that needs to be examined.

It's hard to overstate the power and value of the hardware break and trace facilities. Suppose a programmer knows that a data location occasionally contains an incorrect value but has no idea how it gets there. He can break on writing the suspect value to that location, then examine the trace buffer. Are the data values not changing when they should? Perhaps his program is writing to ROM or jumping into the great unknown. Hardware breaks let the programmer ask questions about the *effects* of malfunctioning programs (or hardware), instead of forcing him to plod through myriad potential *causes*. Furthermore, it all happens in real time—it isn't necessary to stop and look at each potential occurrence for the offending one.

Symbolic Debugging

Just as hardware breaks let the programmer work closer to the problem under investigation, symbolic debugging lets him work in terms of the program as it was written, rather than as it exists in machine language.

The Probe debugger allows the definition and use of symbolic names in addition to numeric values. Such a simple thing, and so tremendously valuable. To avoid conflict with hex

numbers and instruction mnemonics, symbol names are preceded by a period. Thus, it is possible to examine code or data using names that remain constant from version to version, rather than having to learn a new set of magic numbers every time a program is changed and regenerated.

Symbols can be defined interactively or loaded from the load map produced by the DOS linker. The load command has intimate knowledge of the IBM (Microsoft) load-map format. High-level language programs that use large run-time libraries (such as IBM Pascal) will have load maps cluttered with perhaps hundreds of symbols defined in the library, which are of no interest during the debugging session. A utility is provided to process a load map, remove unwanted symbols, and output a revised map. Besides removing the messy clutter, this allows the symbols to fit in the 128K memory on the Probe board with the debugger program.

The debugger can also load module names and source line numbers from the load map. Locations in the program can then be referenced by *..modulename#linenumber* (two periods precede module names to avoid conflict with normal symbols, since a module name and symbol name can legitimately be the same). The command

G =. start, ..main#38

will begin execution at *start* and will break before executing source line 38 in module *main*. As a further convenience, it is possible to specify a current module, then omit the module name in line-number references.

Not all language processors put line-number information in the object files. IBM Pascal, Microsoft Pascal, and Lattice C can include this information, but IBM Fortran cannot.

Symbols and numbers (which can be in binary, decimal, or hex) can be combined in expressions with the standard arithmetic operators (+, −, *, /) and the @ operator, which indicates in-direction. Thus, if *.count* is defined as *DS:43*, then *@B. count* is the contents of the byte at DS:43. and *@W. count* is the contents of the 16-bit word at DS:43 and DS:44.

Macros

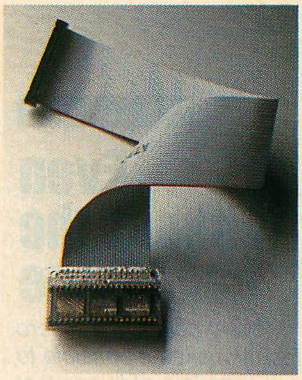
PC Probe permits the definition of command macros, complete with arguments, loops, and conditional execution. More than a nice frill, the macro facility can be used in combination with the powerful breakpoint and symbolic features to create incredibly neat prescriptions. Macros work in a way similar to DOS batch command files, with up to ten arguments designated %0 through %9.

The following example illustrates the power added by macros. Suppose we suspect the subroutine WRITE is being called with VALUE greater than 10, which is out of range for WRITE but not for some other subroutine that also uses VALUE. Hardware breakpoints would let us stop the program on a particular value written to VALUE, but that's both overkill and insufficient. We only want to check the value of VALUE each time WRITE is called, not every time VALUE is changed. Besides, it isn't possible to check for greater than 10 with the don't-care feature; we could check for greater than 8 or greater than 16, but not 10—binary is like that. So what to do?

Suppose we break every time WRITE is about to execute, then check the value of VALUE. That's easy; it's exactly what we do now with DEBUG. But what if it's the eighty-fifth call that's bad, or the twelve thousandth? People should think and computers should work, so let's have the computer help:

```
MAC CHECK =
M- GO .WRITE
M- LOOP WHILE @W.VALUE
   <= 10
M-   GO .WRITE
M- ELOOP
M- PRINT "VALUE out of range,
   = ", @W.VALUE
M- END
```

A utility is provided to process a load map, *remove unwanted symbols, and output a revised map. Besides removing the messy clutter, this allows the symbols to fit in the 128K memory on the Probe board with the debugger program.*



A flat cable attaches a 40-pin plug to the *circuit card. The plug is inserted in the processor socket on the PC motherboard, and the 8088 processor is plugged into a socket on the probe plug.*

An RJ-11 modular phone jack is used to attach *the external button box, shown here. The reset button performs a hardware reset to the PC, while the stop button can be used to force an unconditional breakpoint passing control to the PROBE software.*

Even without the hardware *breakpoints, the macro facility makes it possible to do lots of things that would take forever if done by hand. The programmer's only limitation is his imagination (and the nature of his bugs).*

This macro, named CHECK, GOes until WRITE is about to be executed, then repeatedly checks the contents of the word at VALUE. If it's in range, the loop continues, going until WRITE is reached again. If the value is out of range, the macro exits the loop and prints a message and the offending value. Notice that the program under test will not be executing while the Probe debugger is checking VALUE and looping, so we're not exactly running in real time, but it's a whole lot faster than I can type.

Even without the hardware breakpoints (the preceding example used only simple execution breakpoints), the macro facility makes it possible to do things that would take forever by hand. The programmer's only limitation is his imagination (and the nature of his bugs).

THE HUMAN INTERFACE

The designers of the Probe debugger spent a lot of time and effort designing and building the human interface in an attempt to make it powerful and convenient. They've done quite a good job, though there are a few things I would have done differently. (Show me a programmer who wouldn't say that, and I'll show you a dead programmer.)

The bottom of the screen initially shows a two-line menu of available commands, the last of which is MORE, which displays the rest of the commands. As soon as enough letters have been typed to uniquely specify a command, the menu changes to a two-line summary of the command format and parameters. This built-in help makes reading the manual more than once practically unnecessary.

At the same time the help summary appears, the parameters last used with *this* command are placed on the command line. At this point, typing return will execute the command just as it appears on the screen—i.e., as it was executed previously. I think this sounds more useful than it really is for most commands, but there are times when it's really nice, especially when it is desirable to GO again with the same breakpoints as the time before.

It is possible to do some rudimentary editing of the revived command—use the right cursor key or the space bar to move to the right one field at a time; to move to the left, use the left cursor key. After moving, type. Anything typed causes the deletion of that part of the command line to the right of the cursor. It would be much nicer to have DOS-style editing, with insert, delete, and bidirectional cursor movement. It's especially confusing to alternate between the debugger and the program being debugged and to have to switch editing styles in mid-thought. Cursor positioning is a well-entrenched background task in my brain, and I don't like having to bring it to the foreground when something happens—I'd rather debug the program in the computer than the one in my head.

The command set is rich, and many commands are identical or very similar in format to those in the DOS DEBUG program. One area of difference is the way memory is examined and modified. Here Probe uses the Intel ICE system, rather than DEBUG, as a model. Two commands, BYTE and WORD, display a range of memory as bytes or words, respectively. This is similar to DEBUG's Dump command. A second format allows byte or word data to be entered:

BY address = value [,value . . .]

It's very convenient to be able to enter words right-side up, as it were, rather than having to swap the bytes. It would be nice, though, to see what is there a unit at a time *before* it is changed, instead of having to look at the whole range first, type blindly, and then examine the result.

Other features include assembly, unassembly, fill, move, compare, search, and single-stepping. The STEP command is especially easy to use. The display shows the unassembled instruction about to be executed. Hit RETURN to execute that instruction.

CONCLUSION

The best way to debug a program is not to enbug it in the first place. But for software and hardware developers who need to examine a program (or part of one) that someone else wrote, or who need to look at hardware events, or who are merely mortal and make mistakes, PC Probe is a useful, economical tool.

The people at Atron seem interested in providing a useful product, and they welcome (and act on) customer feedback. Of course, their customers include some important names in PC-dom—such as Microsoft, VisiCorp, and AT&T—whose opinions carry weight with any vendor.

PC Probe is a professional, powerful tool for system testing, and no company serious about developing PC software and hardware should pass it up—it can easily pay for itself in a few hours. Serious amateurs might have a tougher time justifying the cost, but Atron is planning a "software mostly" version for $295 that may well interest such amateurs. This version will have all the symbolic debug capabilities, macros, and the stop/reset box (for bionic breakpoints), but will lack the trace buffer and hardware breakpoints.

All in all, PC Probe is a complete debugging package, easy to use, and useful beyond belief. It's too bad Abe, Ben, and Lefty aren't with us any more—I think they'd like it, too.

PC Probe
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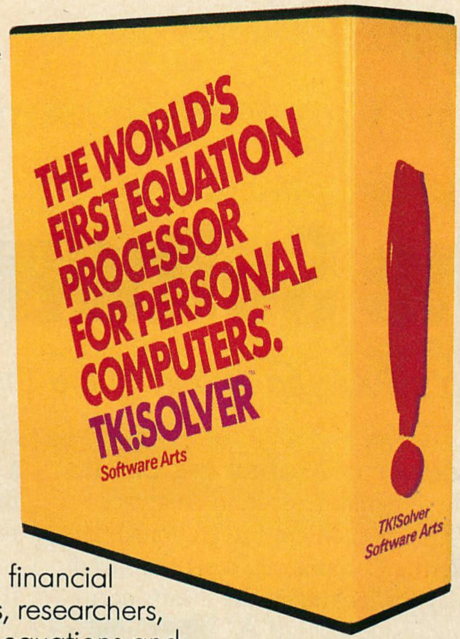

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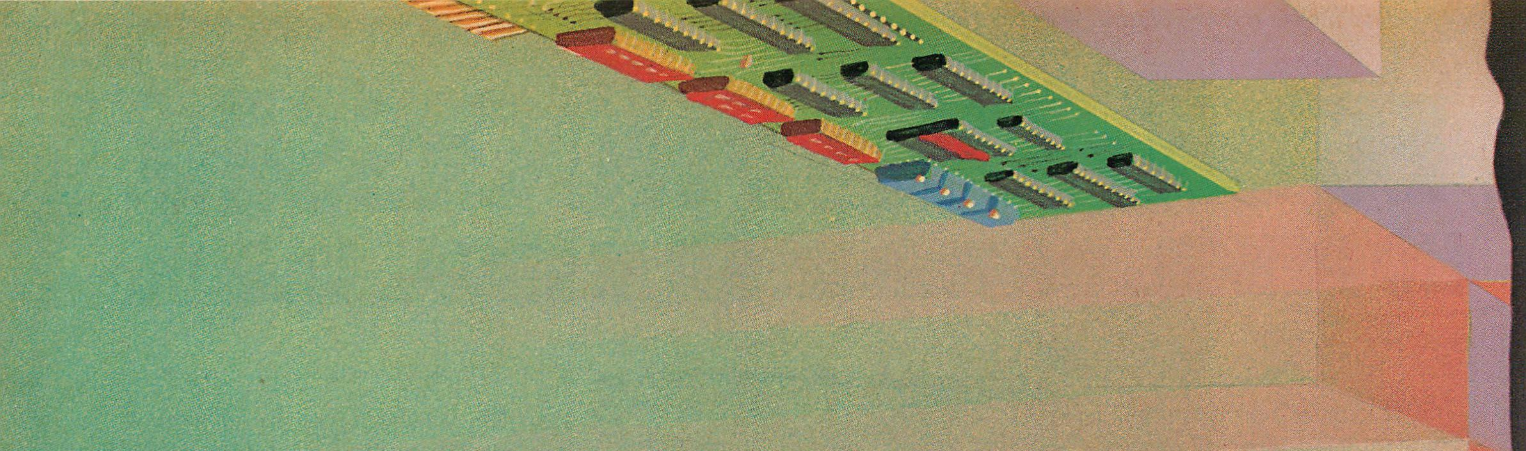


THOMAS V. HOFFMANN

Stalking the Software Bug

Micro Integrations Engineering's PXA: an expert guide through the code jungle

Twenty years ago, more or less, Racquel Welch appeared in the movie *Fantastic Voyage,* based on a novel by Isaac Asimov in which a team of medical technicians get really small and take a perilous journey through some poor guy's capillaries in a vein attempt to cure the common cold. From this unique perspective they gained great insight into the inner workings of the human body and may even have found the bug they sought. In recent years, this theme has been explored further by Steven Martin, the Budweiser Taste Buds, and the movie *Tron,* all of which are entertaining but of dubious utility in computer work.

If the nasty bug you're fighting is a cough due to code, you need something stronger than Dristan and Isolde. One of those cameras from the *Twilight Zone* that takes pictures of the near future or an H. G. Wells time machine with fine tuning would be a good start, but they're somewhat difficult to find.

Thomas Hoffmann is a contributing editor to this magazine.

Tools for Moderate Climes

The Program Execution Analyzer (PXA) from Micro Integrations Engineering Corporation, designed specifically for looking at the events occurring inside an IBM PC, offers similar, if less dramatic, capabilities—and you can actually buy one. The PXA is a single-board logic analyzer that captures data from the PC bus, with software that lets you control the collection and subsequent display and analysis of the data. Bus data is collected in real time, without interference with program execution.

Using the PXA system, the programmer can see memory read and write cycles, including DMA, stack operations, interrupts, and input/output transfers. A useful and unusual feature is the system's ability to retain the collected trace information across a system reset (i.e., rebooting by CTRL/ALT/DEL), which allows a programmer to do postmortem analysis even after catastrophic bugs.

The PXA is not a replacement for a software debugger, but a complementary tool. Because it operates in real time, collecting data without software intervention, it can see things no debugger can: DMA cycles, actual bus timings, and so on. The PXA system provides no means for examining or modifying the program in memory—all analysis with PXA is done from the captured bus information. It is possible to use the PXA in

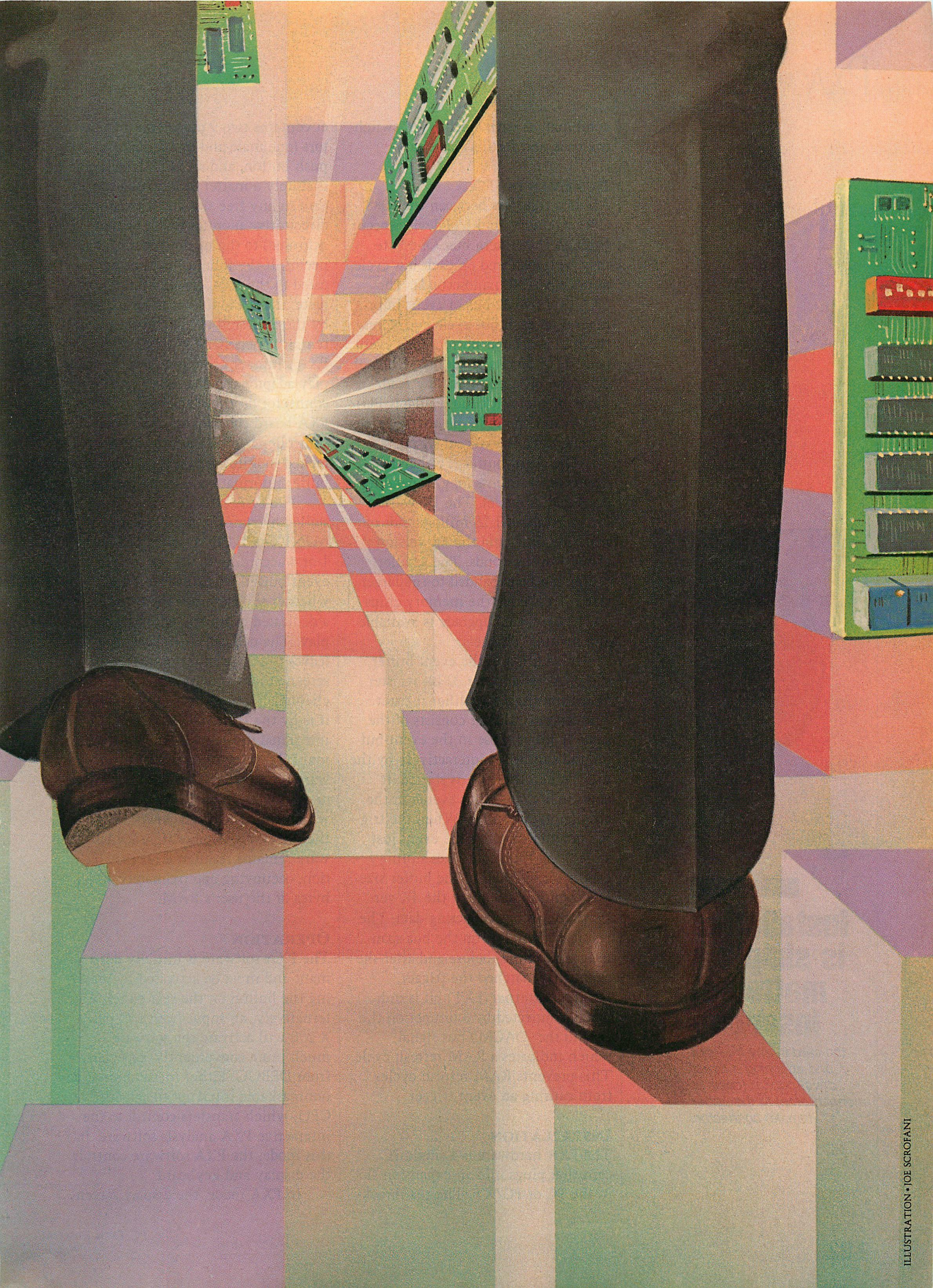
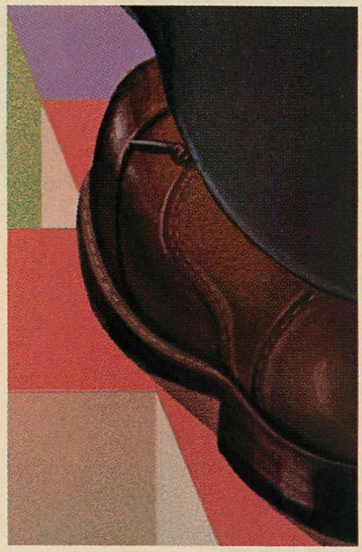


ILLUSTRATION • JOE SCROFANI



Installation is simply a matter of inserting *the card in any free slot and attaching a direct drive monitor (color or monochrome) to the upper (female) connector.*

combination with a debugger, switching back and forth as necessary.

BUS EVENTS

All data transfers between the 8088 CPU, memory, and I/O devices occur through the system bus. One byte may be transferred on each bus cycle, or once per 840 nanoseconds. The PXA captures 32 bits of event information on each bus cycle and stores them in a circular buffer. Each event consists of 20 bits of address; 8 bits of data; one bit each indicating read/write, memory/IO, and regular (CPU)/DMA; and one more bit that may be attached to any external signal.

The event buffer is either 1K events or 4K events long, depending on the PXA model. The 1K version can store about 1.25 milliseconds of machine time, and the 4K version about 5 milliseconds. The smaller buffer can be expanded to the larger size by replacing the memory chips on the card; this upgrade is available at a nominal charge.

In addition to the event buffer, the PXA has another 32-bit register called the trigger qualifier register. The trigger qualifier consists of the same fields as those in the event buffer and can be set interactively by the user. When the PXA is started, it continually stores bus events in the circular event buffer. When the trigger qualifer matches the event just stored, the PXA continues storing events for one half of the buffer size (2K events or 2.5 ms in the 4K version), then stops collecting data. The result is a window on the bus spanning equal times before and after the event that matched the trigger.

The external (EXT) bit is ordinarily connected by a jumper on the card to the -DACKO bus signal, which indicates a RAM refresh cycle. This prevents RAM refresh cycles from causing an event trigger.

INSTALLATION

The PXA hardware is a single PC card that plugs into an expansion slot in the PC or PC/XT. The rear bracket contains two 9-pin monitor connectors (one male and one female), a push button, and an LED. Installation is simply a matter of inserting the card in any free slot and attaching a direct drive monitor (color or monochrome) to the upper (female) connector. If the monitor is to be dedicated to the PXA, installation is complete. If the monitor is to be shared by the PXA and the PC's display system, it is necessary to attach the PXA's jumper cable between the display adapter and the lower (male) connector on the rear bracket. The PXA board contains its own video controller, which operates the attached monitor whenever the trace buffer information is being displayed.

The PXA software driver is installed by running the program RUNPXAxN.COM, where **x** is either 1 or 4 according to the size of the event buffer. The software asks whether the system is to be run with a dedicated or integrated (shared) display. The dedicated display mode leaves the trace information on the screen at all times (unless DMA channel 1 is used by your system, as it is by the IBM SDLC adapter). The integrated display will show the normal PC display until the PXA software is entered (either automatically or manually via the push button), at which time the display switches to the PXA trace display. The PXA software remains resident after installation, occupying approximately 13.5K bytes of the user's RAM.

OPERATION

The PXA software is initially dormant and must be activated by pressing the button on the rear panel. Alternatively, an input from I/O port X'250 will activate the software much more conveniently, especially from DEBUG. Either method sends a nonmaskable interrupt to the 8088 CPU, which transfers control to the interactive PXA analysis software. In this mode, the PXA software controls the display and keyboard.

In PXA mode, the display screen

appears as in photo 1. The lower 19 lines display event information from the trace buffer, and the upper portion shows the trigger qualifier components and control information, followed by the register and flag status when the PXA handler was entered.

The Fields on the Bus Go Round and Round

The first six fields in the upper portion of the display comprise the trigger qualifier. The current field is denoted by a reverse-video label. The qualifier and control fields can be modified using the top row of numeric keys, letters, and some of the cursor pad keys. Nine of the ten function keys on the left and eight of the numeric/cursor pad keys are used for control and analysis functions.

The address field may be entered directly as a five-digit physical address or may be entered as two four-digit segment/offset values. Any digit in the qualifier may be an asterisk (entered with the space bar!), which indicates a don't care condition—any value will match. This allows the user considerable flexibility in specifying the trigger condition.

Entering or modifying data in the qualifier or control fields is simple. The left and right cursor keys select the current field, which is denoted by a reverse-video legend. Each digit typed (hex or decimal as appropriate) always appears in the rightmost position in the field, with the previous contents shifted one position to the left. The high-order digit is discarded. Some programmable logic analyzers work in a similar way, so engineers used to such equipment may be comfortable with this method. I found it a little too spartan—I kept entering three-digit numbers in five-digit fields without looking, only to discover that two digits left over from the previous value were appended to the left, requiring me to reenter all five digits, leading zeroes and all. I stumbled less as I got used to it, but these seemingly minor details divert attention from the real work of debugging and slow down the process.

The length of the preceding complaint is somewhat out of proportion to its significance in relation to the PXA's capabilities. One nifty feature (selected by setting the DNOT TRIG field to Y) is the ability to trigger on bus data having any value *other* than that specified in the qualifier.

Once the qualifier and option fields are set, pressing F1 arms the trigger comparators, starts event collection, and returns to the interrupted program. Trace collection continues until the Nth occurrence (determined by the TRIG DELAY field) of a qualifying event, plus one-half of the event buffer. If automatic switching is enabled (AU/SW = Y), the PXA enters analysis mode immediately after collection stops (*not* immediately after the triggering event); if automatic switching is not enabled, manual entry by push-button or input is required. The PXA signals completion by flashing the word TRIGGER in the upper right of a dedicated display or by lighting an amber LED on the rear connector panel.

Once back in PXA mode, the screen will show the trigger information and CPU registers in the header area, as well as 19 lines of event buffer. The registers indicate the CPU state at the time the PXA software was entered, which is the point at which execution will resume when the analysis mode is exited. Note that this has nothing to do with the triggering event—the registers may indicate a state that existed minutes later than the last event in the buffer if PXA was entered manually.

The user can navigate through the trace buffer by scrolling a line at a time (with the right-hand + and − keys), moving a 19-line page at a time (with PgUp and PgDn), or moving directly to the first trigger event (Home) or the last event captured (End). Each event line is numbered in the first display column; negative numbers precede the trigger, and positive numbers follow it. Event +0000 is the event that caused the primary

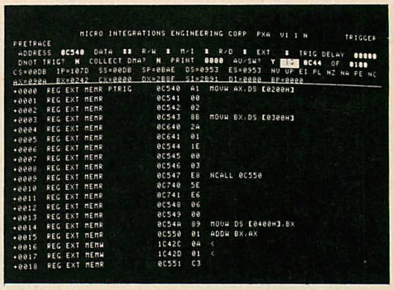


Photo 1:
Display Screen in PXA Mode

One really nifty feature (selected by *setting the DNOT TRIG field to Y) is the ability to trigger on bus data having any value* other *than the value that was specified in the qualifier.*

SCREEN PHOTOS • BLAKESLEE-LANE, INC.

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trigger and is labeled PTRIG. Subsequent events that also match the trigger qualifier are tagged STRIG. This makes it easy to spot loop iteration or repeated accesses to an interesting memory location or I/O register.

It is also possible to search the event buffer for any event by using the trigger qualifier fields and the search function key (F5). The software will scan the buffer and mark matching events with PTRIG or STRIG. Subsequent searches with the same qualifier will position the display to the next occurrence of the matching event. This greatly speeds up the process of getting to the interesting region of the buffer.

The PXA software also permits up to eight software breakpoints (called pretrace breakpoints) to be set. When executed, these breakpoints cause immediate entry into PXA mode, with the registers displayed indicating the status at the time of the breakpoint. The entire trace buffer contains events leading up to the breakpoint; no subsequent events are collected. These breakpoints are useful for looking further back in time than is possible with the normal trigger mechanism, but they are restricted to execution breaks only. Pretrace breakpoints cannot be used in combination with DEBUG, since both of these programs require the breakpoint interrupt vector.

Curiously, the software leaves the event-number field blank when displaying the results of a pretrace breakpoint. This makes it easy for the user to lose track of his place when scrolling through the buffer. The obvious improvement would be to number the events with the correct negative numbers, say from −4095 to +0000. This, plus a way to position by event number, would make buffer navigation easier.

States Incongruous Assembled

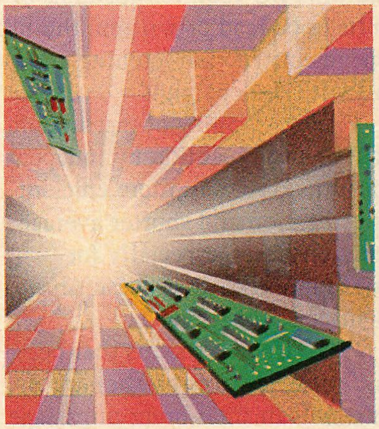
The event buffer display starts out with the event number, type, address, and data fields filled in and the assembly field blank. The PXA has no way of telling which memory reads are instructions and which are operands, so that distinction is left to the user. To disassemble a sequence of instructions, scroll the display to position the first byte at the top of the event area, then press F10. The PXA will display the assembly language equivalent for a contiguous sequence of bytes starting from that point. Memory write cycles are flagged by a < symbol, to make it easier to find instruction candidates. If the user mistakenly starts disassembly in the middle of an instruction, he'll get an erroneous display, but it's easy to undo. Pressing F10 when positioned to an event with an instruction displayed will clear that and subsequent instructions in the contiguous area.

Each path through the instruction stream must be disassembled individually; the PXA won't automatically find the destination of transfers—such as calls, jumps, returns, or interrupts—though it does display the destination address for jumps and calls. This is one of the more tedious aspects of using the PXA, but it is largely unavoidable. To understand why, it is necessary to understand the interaction between the 8088 CPU and the memory bus.

Microprocessors typically execute their programs by repeating the following steps:

1. Fetch an instruction from memory
2. Decode the instruction (i.e., decide what to do)
3. Fetch any operands required from memory
4. Perform the operation
5. Store the result in memory if required

Most 8-bit processors perform these steps sequentially, with perhaps one bus cycle of overlap. In the 8088, these operations are divided between two independent units in the same CPU chip. The execution unit (EU) executes instructions; the bus interface unit (BIU) reads and writes to memory for instructions, operands,



Each path through the instruction *stream must be disassembled individually; the PXA won't automatically find the destination of transfers—such as calls, jumps, returns, or interrupts—though it does display the destination address for jumps and calls.*

and results. The EU has no direct connection to memory, depending on the BIU for all interactions with the outside world. The EU reads instructions from a 4-byte instruction queue that is filled by the BIU. When the EU is busy executing instructions, the BIU can look ahead and fetch more instruction bytes from memory. When the EU requires operands or results to be read or written, the BIU suspends instruction-fetching and deals with the operands.

The overlapping of instruction fetching and execution by independent units results in more efficient bus utilization and shorter average execution times, especially for straight-line code that doesn't have any jumps. This is good.

What isn't so good is that because the PXA lives on the bus, it sees events in their order of passage through the BIU, not the EU. The difference is illuminating and somewhat confusing. Consider the simple program in listing 1, which loads two words from memory, calls a subroutine to add them together, and then stores the result. Listing 1 shows the program as it appears in memory, unassembled by DEBUG, and listing 2 shows the instructions in the order of execution. At first glance, it might seem logical to expect the operands to be read or written immediately after the instruction that needs or supplies them (listing 3), but it's not that simple. The BIU look-ahead feature results in several instruction bytes being fetched before the first is completely executed. The actual order is shown in listing 4.

Notice how some instructions (the MOV after the CALL, for example) are fetched once and not executed, then fetched again later. This is because the BIU simply fetches instruction bytes sequentially until the EU tells it to fetch elsewhere—the BIU has no idea what the instructions mean.

This simple example illustrates the difficulty with external analysis of pipelined computers. Matching instructions and operands requires the identification of two separate, but interleaved, streams of operations and the discarding of spurious fetches that are never executed. The example also illustrates why accurate *a priori* estimates of execution times are difficult; the overall timing depends on the surrounding instructions.

Bus Stop

The PXA with 1K buffer, software, monitor cable for integrated display, and 24-page installation and operation manual is $750. The 4K version is $950. Micro Integrations will also sell the Amdek 310A high-resolution monochrome monitor (with amber phosphor) for $155 if purchased with either PXA system. The unit we tested worked quite well; if you need a PXA and a monitor, this is a pretty good deal.

This tool isn't for everyone. The view from the bus can be confusing, because it doesn't quite match the execution path and because operands lag behind their associated instructions. The manually guided disassembly required can be tedious, especially with the 4K buffer option. Despite these drawbacks—which, it should be emphasized, are largely the result of the way the 8088 works and not of flaws in the PXA design or implementation—the PXA is a powerful tool for specialized real-time event analysis, with many features not found in much more expensive general-purpose testing equipment. Programmers in the business of developing PC hardware and software systems should seriously consider adding a PXA to their toolkits.

Program Execution Analyzer
Micro Integrations Engineering Inc.
11 Clearbrook Road
Elmsford, NY 10523
914-592-8989

CIRCLE 499 ON READER SERVICE CARD

Listing 1 Adding Program, In Unassembled Form

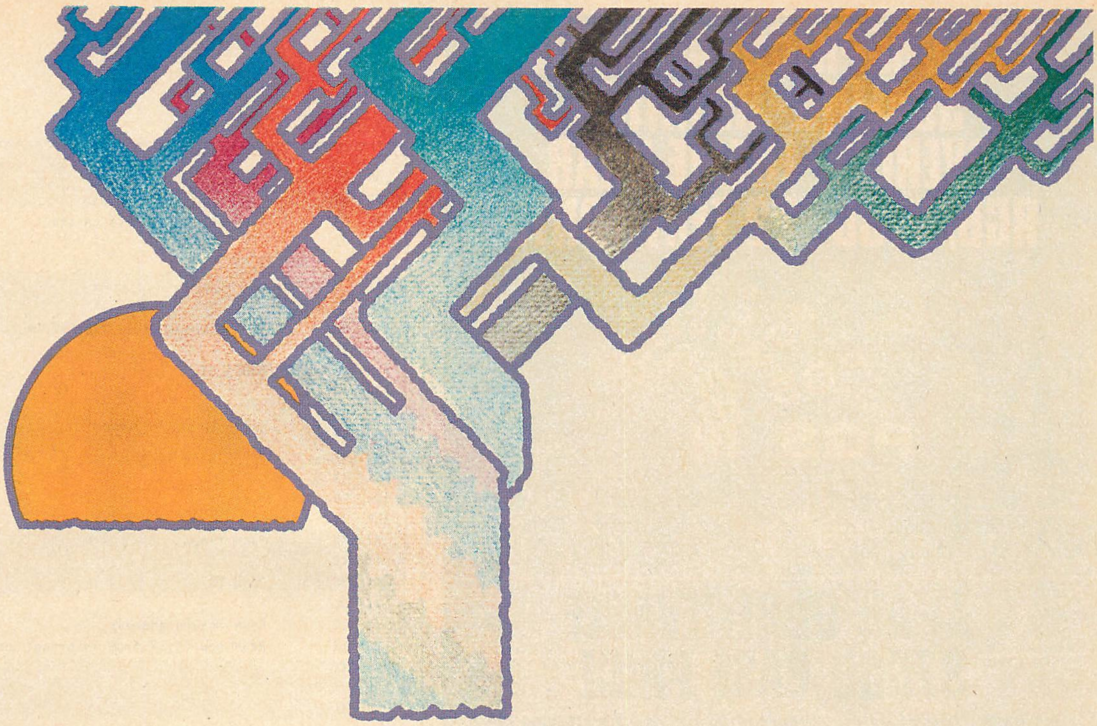
```
0C9C:0100 A10002     MOV   AX,[0200]
0C9C:0103 8B1E0003   MOV   BX,[0300]
0C9C:0107 E80600     CALL  0110
0C9C:0110 01C3       ADD   BX,AX
0C9C:0112 C3         RET
0C9C:010A 891E0004   MOV   [0400],BX
0C9C:010E CD20       INT   20
```

Listing 2 Adding Program, in Order of Execution

```
0C9C:0100 A10002     MOV   AX,[0200]
0C9C:0103 8B1E0003   MOV   BX,[0300]
0C9C:0107 E80600     CALL  0110
0C9C:010A 891E0004   MOV   [0400],BX
0C9C:010E CD20       INT   20
0C9C:0110 01C3       ADD   BX,AX
0C9C:0112 C3         RET
```

Listing 3 Expected Order of Instructions for Adding Program

```
100  A1   MOV AX,[0200]
101  00
102  02
200  XX        Read data from 200
201  XX
103  8B   MOV BX,[0300]
104  1E
105  00
106  03
300  XX        Read data from 300
301  XX
107  E8   CALL 0110
```



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```
108  06
109  00
 XX  0A        Push return address on stack
 XX  01
110  01   ADD BX,AX
111  C3
112  C3   RET
 XX  0A        Pop return address from stack
 XX  01
10A  89   MOV [0400],BX
10B  1E
10C  00
10D  04
400  XX        Write data to 400
401  XX
10E  CD   INT 20
10F  20
 XX  XX        Push flags
 XX  XX
 XX  9C        Push CS
 XX  0C
 XX  10        Push return address
 80  XX        Read new CS:1P from interrupt vector
 81  XX
 82  XX
 83  XX
```

Listing 4 Actual Order of Instructions for Adding Program

```
+0000 REG EXT MEMR PTRIG  0CAC0 A1 MOV AX,DS:[0200H]
+0001 REG EXT MEMR        0CAC1 00
+0002 REG EXT MEMR        0CAC2 02
+0003 REG EXT MEMR        0CAC3 8B MOVW BX,DS:[0300H]
+0004 REG EXT MEMR        0CBC0 00
+0005 REG EXT MEMR        0CBC1 B9
+0006 REG EXT MEMR        0CAC4 1E
+0007 REG EXT MEMR        0CAC5 00
+0008 REG EXT MEMR        0CAC6 03
+0009 REG EXT MEMR        0CAC7 E8 NCALL 0CAD0
+0010 REG EXT MEMR        0CCC0 E8
+0011 REG EXT MEMR        0CCC1 D8
+0012 REG EXT MEMR        0CAC8 06
+0013 REG EXT MEMR        0CAC9 00
+0014 REG EXT MEMR        0CACA 89 MOVW DS:[0400H],BX
+0015 REG EXT MEMR        0CAD0 01 ADDW BX,AX
+0016 REG EXT MEMW        1C9AC 0A <
+0017 REG EXT MEMW        1C9AD 01 <
+0018 REG EXT MEMR        0CAD1 C3
+0019 REG EXT MEMR        0CAD2 C3 NRET
+0020 REG EXT MEMR        0CAD3 00
+0021 REG EXT MEMR        1C9AC 0A
+0022 REG EXT MEMR        1C9AD 01
+0023 REG EXT MEMR        0CACA 89 MOVW DS:[0400H],BX
+0024 REG EXT MEMR        0CACB 1E
+0025 REG EXT MEMR        0CACC 00
+0026 REG EXT MEMR        0CACD 04
+0027 REG EXT MEMR        0CACE CD INT 20H
+0028 REG EXT MEMR        0CACF 20
+0029 REG EXT MEMW        0CDC0 E8 <
+0030 REG EXT MEMW        0CDC1 91 <
+0031 REG EXT MEMR        0CAD0 01 ADDW BX,AX
+0032 REG EXT MEMR        0CAD1 C3
+0033 REG EXT MEMR        00080 FB
+0034 REG EXT MEMR        00081 0B
+0035 REG EXT MEMR        0CAD2 C3 NRET
+0036 REG EXT MEMR        00082 DB
+0037 REG EXT MEMR        00083 00
+0038 REG EXT MEMW        1C9AC 87 <
+0039 REG EXT MEMW        1C9AD F0 <
+0040 REG EXT MEMW        1C9AA 9C <
+0041 REG EXT MEMW        1C9AB 0C <
+0042 REG EXT MEMR        019AB B4 MOVB AH,00H
+0043 REG EXT MEMW        1C9A8 10 <
+0044 REG EXT MEMW        1C9A9 01 <
+0045 REG EXT MEMR        019AC 00
+0046 REG EXT MEMR        019AD EB JMPS 019CF
+0047 REG EXT MEMR        019AE 20
+0048 REG EXT MEMR        019AF 80 CMPB AH,57H
+0049 REG EXT MEMR        019CF E8
```

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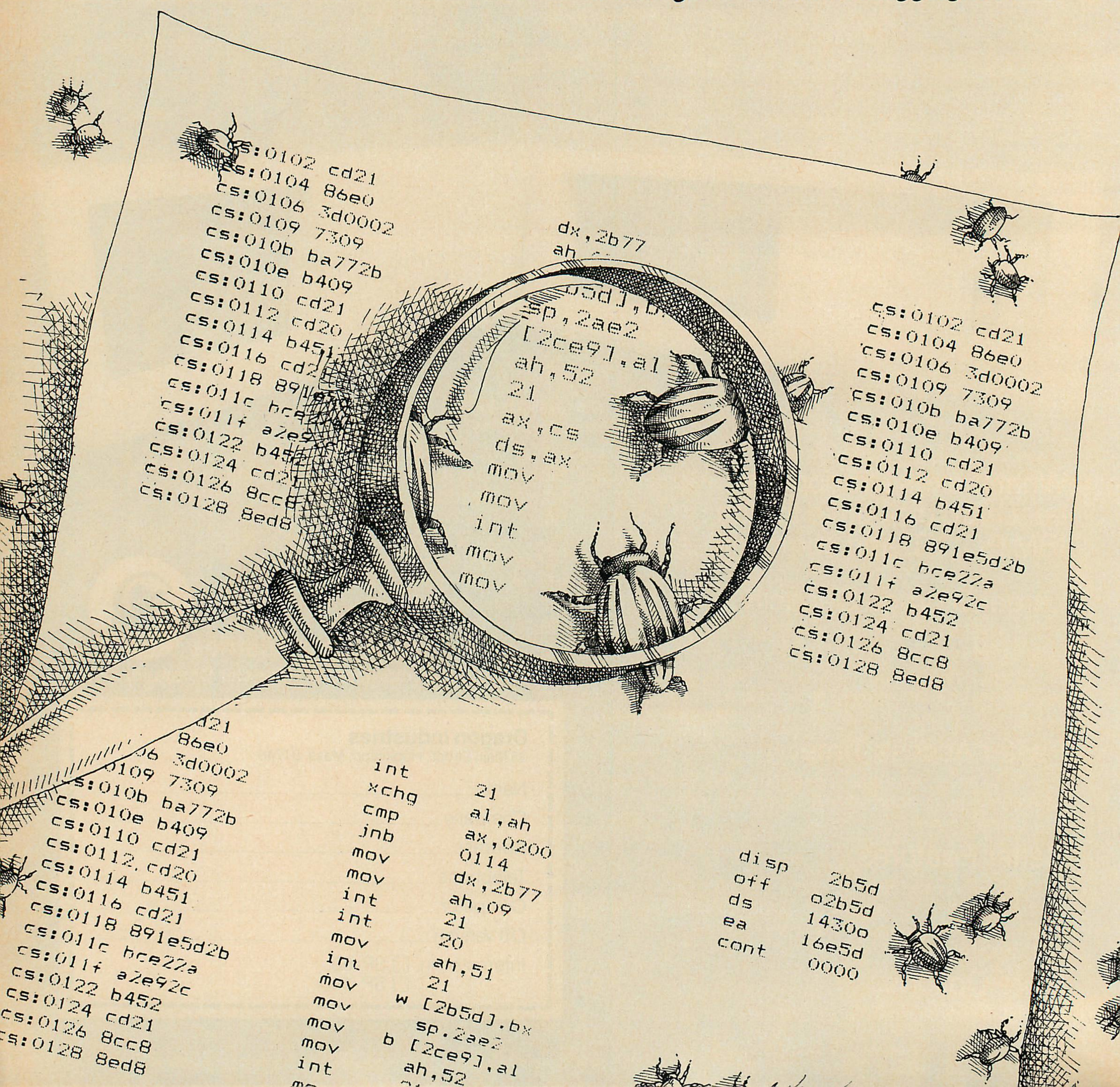
Two new ways to drive the bugs away

Codesmith-86 and Trace86 are a powerful pair in a new generation of debugging tools



RAY DUNCAN

Although assembly language has been pronounced dead many times by various computer science pashas and other admirers of high-level languages, it continues to fill a vital spot in the armamentarium of programming tools. Even on the IBM Personal Computer, a business-oriented microcomputer if ever one existed, the Microsoft Macro Assembler maintains month after month a solid spot in the Softalk listings of top 30 programs.

Why does assembly language programming continue to thrive? The reasons are complex. Another glance at the listing of the top 30 programs reveals that the most flexible, speedy, and space-efficient application software is still written by experienced assembly language programmers with a deep understanding of the architecture of their target computers (Lotus 1-2-3 and the Flight Simulator are good examples).

Those of us who persist in twiddling bits were lucky that the IBM PC came along. It is the first microcomputer with the power, memory space, and high-speed display—as well as the huge number of units sold—required to entice talented programmers into creating a new generation of assembly language debugging tools. Within the last few months, two powerful memory-mapped program-tracing utilities have appeared on the market: "Trace86," written by Neil Bennett and distributed by Morgan Computing Company; and "Codesmith-86," written by Erik Osborn and distributed by Visual Age.

A side-by-side comparison of Trace86 and Codesmith-86 is instructive on many levels. They were written to run on identical hardware and operate on exactly the same target programs. Their authors unquestionably set out to create these programs using the same basic development tools and with highly similar needs and objectives, yet the two programs are very different in their user interaction, their style of display presentation, and the types of debugging for which they are best suited. I have been programming in assembly language at the systems level for about twelve years, on a variety of mini- and microcomputers. In fact, one of the first programs I ever wrote was a two-pass assembler that was coded directly in hexadecimal machine language for the Raytheon 703 minicomputer (bet you never heard of that one). Because of my experience in this area, I jumped at the chance to evaluate Trace86 and Codesmith-86 and put them to use in my own work for a number of weeks.

In the illustrations for this article, I have used a small utility of my own called VMODE, which simply calls the IBM ROM BIOS to set the video display mode according to a command-line parameter in the range 0-7. A fragment of the listing for the original program, corresponding to what is visible in the screen dumps, is shown in listing 1.

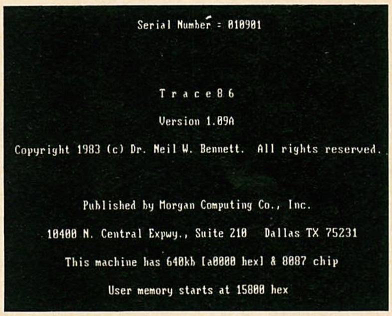
The most flexible, speedy, and *space-efficient application software is still written by experienced assembly language programmers with a deep understanding of the architecture of their target computers.*

USING CODESMITH-86

In order to run Codesmith-86, the files CSM.EXE, CSINI1.EXE, and CSM.ICS all must be present on the same disk drive. The first file is the actual trace utility, the second is an initialization overlay, and the third is a "configuration file" that specifies certain aspects of the debugging environment. To get started, simply enter CSM followed by the name of the program to be traced and any command tail that is to be passed to the traced program. For example:

A>CSM MYPROG.COM TEST.DAT <return>

A sign-on message appears, followed by a rather complex display initially divided into two windows (see photo 1). The upper window is the "command" area and contains a cue mark ">" as well as displays showing the



Intro screen *for Trace86 on a computer with an 8087.*

Ray Duncan is a contributing editor to this magazine. His company, Laboratory Microsystems, does custom programming for medical applications.

ILLUSTRATIONS • CATHERINE KANNER

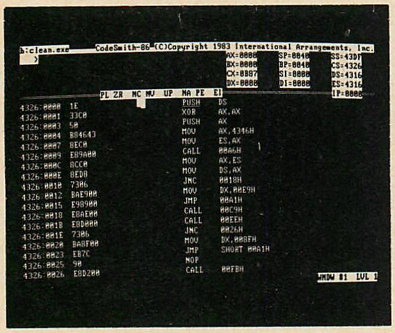


Photo 1:

Initial display screen for Codesmith-86, showing the upper "command" window and the lower "tracing" window. Note that the traced program's stack pointer has been set to an illegal address by the initialization routine.

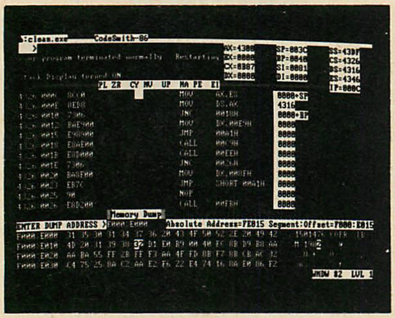


Photo 2:

The same display screen for Codesmith, after some configuration commands have been entered and an additional window has been opened to display the contents of memory.

state of all registers and flags. The lower window is the "trace" area and initially contains a disassembly of the beginning of the program. The next instruction to be executed is underlined, and a reverse-video box is a working cursor that is used to designate instructions for breakpointing, to scroll through the program, and to delimit the size of memory dump windows when they are opened.

It is possible to move back and forth through the entire range of the program with the arrow and page keys, inspecting the code and setting breakpoints with the "Alt-B" command wherever it seems appropriate. Instructions can be "tagged" with numbers ranging from 1 to 99; several instructions can share the same tag number, and breakpoints can be enabled or disabled for a given tag simultaneously. The radix of each disassembled instruction can be individually set to binary, octal, decimal, or hexadecimal for maximum readability. And when data areas being disassembled into nonsense instructions are found, those lines can be flagged with one keystroke to be displayed as "DB" or "DW' pseudo-ops.

Before starting to execute a program, the user may wish to turn on the "step over CALL/INT/RET" mode, which causes tracing to be suspended during calls to subroutines or the operating system. He may also wish to enable the dynamic stack display with the "Alt-S" command. If necessary, it is possible to open a third memory display window that will display the context and contents of memory locations accessed by the traced program (see photo 2). The contents of memory shown in such a window can be edited directly simply by positioning the cursor over a byte with the arrow keys and typing in the new contents.

Another decision involves whether the program's video output should be captured (Screensave Mode ON); this slows down program tracing but avoids confusing overwrites on Codesmith's display. Lastly, make sure that the registers contain the proper values; they can be modified by moving the cursor to the "command" window with the F2 key and entering DEBUG-like "R" sequences.

When these parameters, along with any desired breakpoints, have been set, Alt-X can be entered to execute the program at full speed until a breakpoint is encountered, Alt-A can be used to trace continuously with each step displayed, or "INS" followed by the "+" key can be entered to single-step manually through the program's code.

Codesmith really shines when it is used to decipher an unknown object program for which there is no source listing available. Moving back and forth through the disassembly without executing anything is almost like paging through a printout of the program; it facilitates rapid understanding of the code. As the function of each instruction and subroutine is established, free-text comments can be added to as many lines as desired; these comments will be retained throughout the tracing session. When a reasonably sized block of program has been decoded, it can be written into a disk file, complete with comments, either in a "normal" format (listing 2) or in a special format for eventual reassembly (listing 3).

USING TRACE86

The only file a user needs on his disk to use Trace86 is T86.EXE, which is about one-third the size of the combined Codesmith program files. When the utility is invoked, it presents a brief sign-on message and then a blank screen with a cue mark ">" in the upper left-hand corner. This "command" screen is used to request the loading of programs, set and display breakpoints, configure memory displays, and so forth.

Typically, the user would begin by loading a program (either EXE or COM types are acceptable), selecting a few breakpoints, choosing an area of memory to be monitored on the trace screen, and perhaps entering

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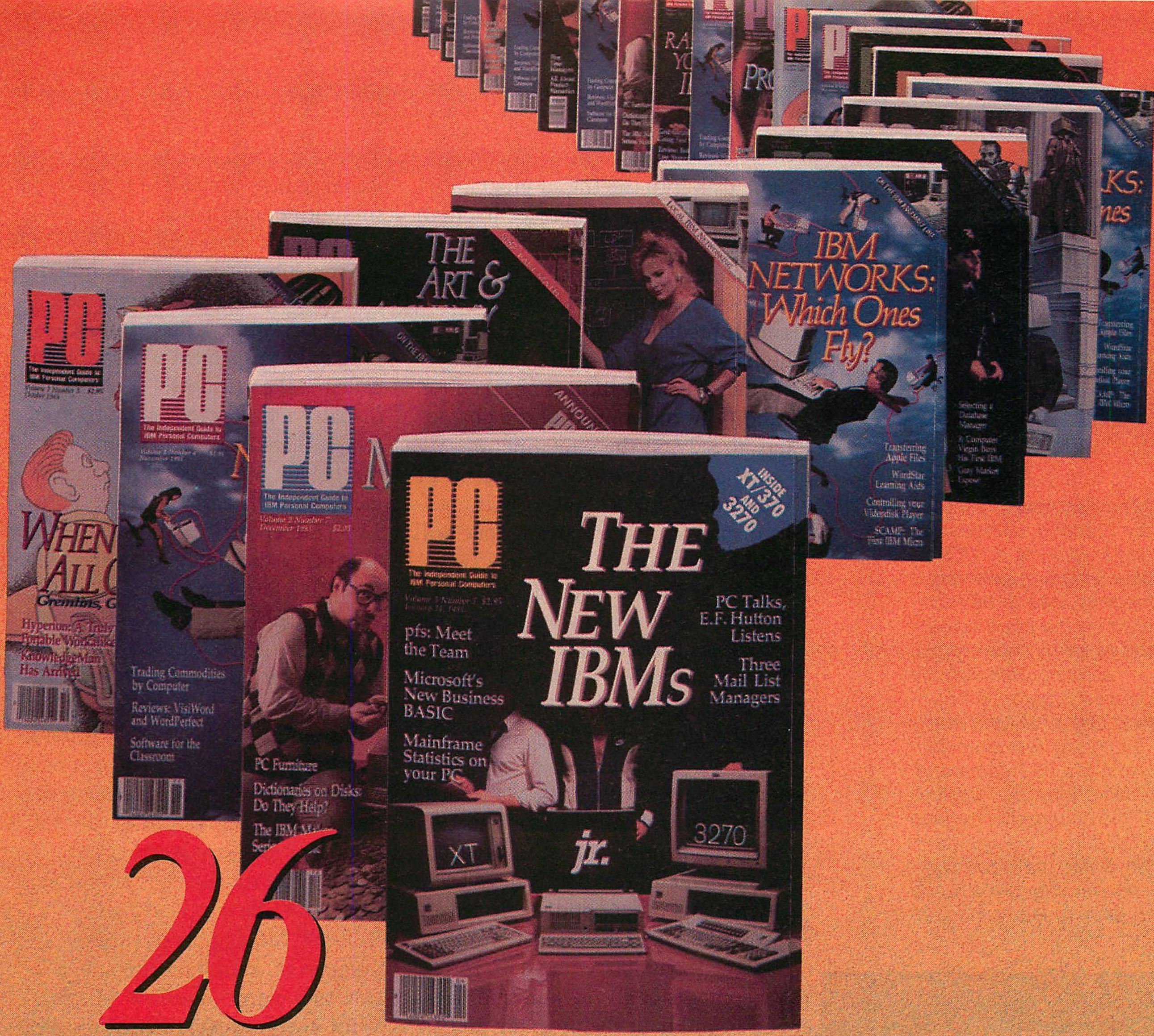

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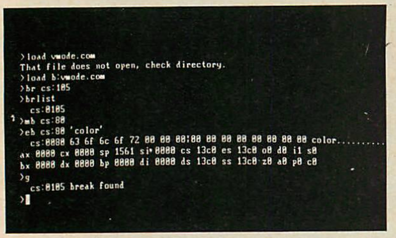

Photo 3:

The "command screen" for Trace86, demonstrating loading of a "COM"-type program, selecting a memory area to be monitored on the trace screen, setting some breakpoints, entering data into the traced program's "command tail" area, and finally beginning fast execution with the "G" command. Also shown are displays of the changed command tail and of the registers. The codes may look cryptic, but they are actually easy to learn and use.

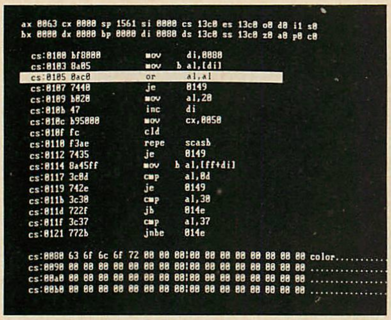

Photo 4:

The "trace screen" for Trace86, which displays the registers and flags, a disassembly of the currently traced fragment of code, and a hex and ASCII dump of the memory region selected with the "mb" command in photo 3. Notice the reverse-video bar that highlights the instruction to be executed next.

some data into the traced program's Program Segment Prefix (see photo 3).

As the user types in the various commands, he will encounter a system of syntax checking that I feel safe in predicting is unlike any other he has ever experienced. As each character is entered, it is checked for validity in the context of the characters already on the same line.

If a key is pressed that doesn't fit the context, that character will not be displayed, and a warning tone will sound; pushing an invalid key twice will cause the message "TRY" to be displayed, followed by a list of all the characters that could legally be used. To back out of the command, just hit ESCape; the offending line is deleted and the screen cleaned up as though nothing ever happened. A set of help menus is always available via the F9 key, and it is detailed enough to make the manual almost unneeded.

When all breakpoints have been entered and other options selected, just strike ENTER to transfer to the "tracing screen" (see photo 4). Here the contents of all registers and flags, a disassembly of the program, and an optional hex and ASCII dump of a selected memory area are displayed. A reverse-video bar is placed over the next instruction to be executed. The user can single-step by pushing the space bar, execute continuously by pressing ENTER, or return to the "command screen" by pressing the ESCape key. Alternatively, a program can be executed up to a breakpoint at full "native" speed by entering "G" on the original "command screen." Tracing "frames" can be audited to the line printer as needed with the "P" command.

While the program is executing, a stack display and memory address calculation display appear and disappear dynamically on the tracing screen. If the program enters a loop or subroutine through which single-stepping doesn't seem desirable, it is possible to press "C" (for loops) or "K" (for subroutines) to finish execution at full processor speed; single-stepping is resumed when the loop or subroutine terminates.

When a programmer is sure that a given subroutine contains no errors, he can designate it as "fast" with a single keystroke, causing single-stepping to be suspended whenever it is called. All software INTerrupt calls (usually requests for operating system services) are "fast" by default, but can be designated as "slow" for single-stepping if desired.

Trace86 qualifies as a disk utility as much as a debugging utility. An extensive set of commands is available to load COM or EXE files, read/modify/write absolute disk sectors, and transfer large areas of memory contents to and from disk data files. Disassembled code can be written to a disk file (although it will not be in a form that can be readily reassembled—see listing 4), and so can ASCII dumps of memory areas.

A program listing is almost mandatory for efficient work with Trace86. Moving about through a program or setting breakpoints is slow and painful without a listing. With one, however, Trace86 is pleasant to use and almost unbelievably powerful. The displays are well organized and blindingly fast, and the command set is extensive.

MEMORY DUMPS

As was briefly mentioned above, Codesmith-86 allows a variable part of the tracing screen to be allocated for one or two windows that display an area of memory in hex and ASCII. Within each window, up to eight alternate areas of memory can be displayed, and it is possible to rotate between those areas with a function button. One of the windows can be coupled to the trace with the AUTODUMP command: while single-stepping, each reference to memory by the traced program causes that area to be displayed in the selected window; the actual byte or word accessed is accented by reverse video.

Trace86 allows only one area of memory to be specified at a time;

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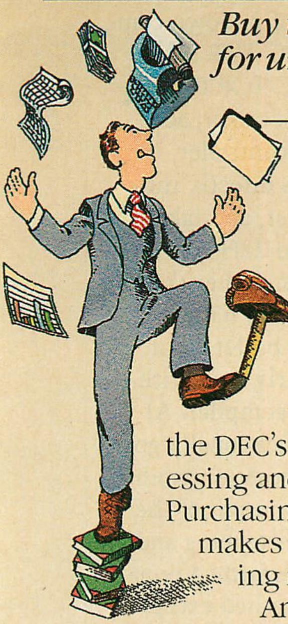

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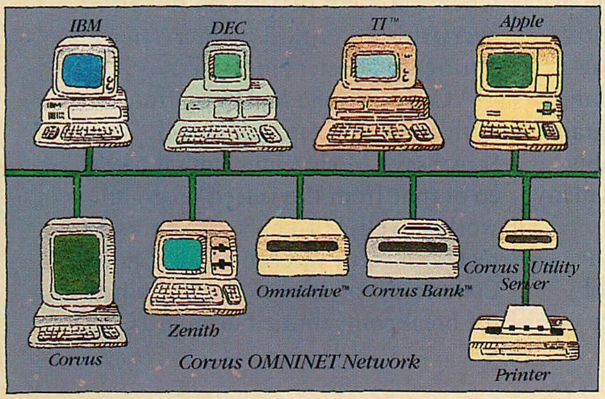

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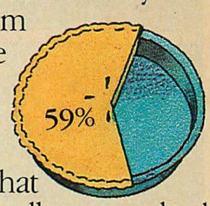

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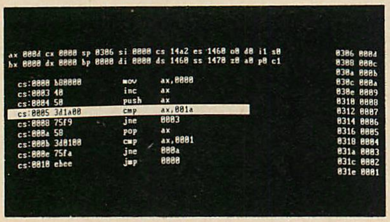
that area will be monitored at the bottom of the trace screen. Selection of byte or word format, along with an optional sidebar giving the dumped area's equivalent in ASCII or the entire PC graphics character set, is controlled with function buttons.

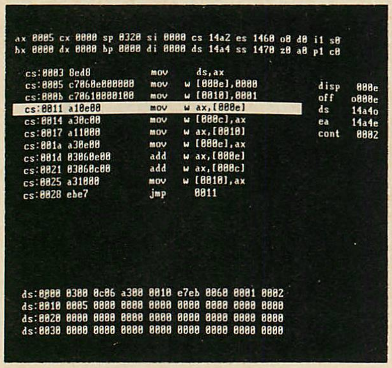
DOCUMENTATION

Trace86 offers a 40-page, typeset, spiral-bound manual. It includes a table of contents, a tutorial section with instructions on running sample programs, and detailed explanations of commands. In addition, it has a brief description of the theory of operation, a discussion of potential trouble points and limitations in tracing programs, a summary of commands and special keys, and an index. The manual is well organized and readable. Paradoxically, since Trace86 has excellent on-line help screens, the manual is rarely needed.

Codesmith-86's documentation is disappointing—it consists of a 30-page, typewritten, photocopied, stapled booklet without covers or binding. Included in it are a table of contents, a description of configuration files, pointers on tracing and setting breakpoints, instructions for dumping and changing memory contents directly, and an explanation of "command mode" functions. An incomplete summary of commands and special keys is supplied as an extra loose page. I felt the text was poorly organized, contained a lot of jargon, and in general was not very enlightening. The manual has no index.



The displayed program demonstrates PUSHing and POPing of the stack, the results of which are dynamically displayed on the far right of the screen.



This trace screen shows the effective address calculation for the highlighted instruction. Notice the memory display area, which is organized by words to reflect the execution of the program.

EVALUATING THE TWO UTILITIES

In order to evaluate the operation of Codesmith-86 and Trace86, I first tried the examples in the manuals and sample programs to make sure they worked as stated. Both programs made it past this point comfortably, something that can't be said for many other products on the market.

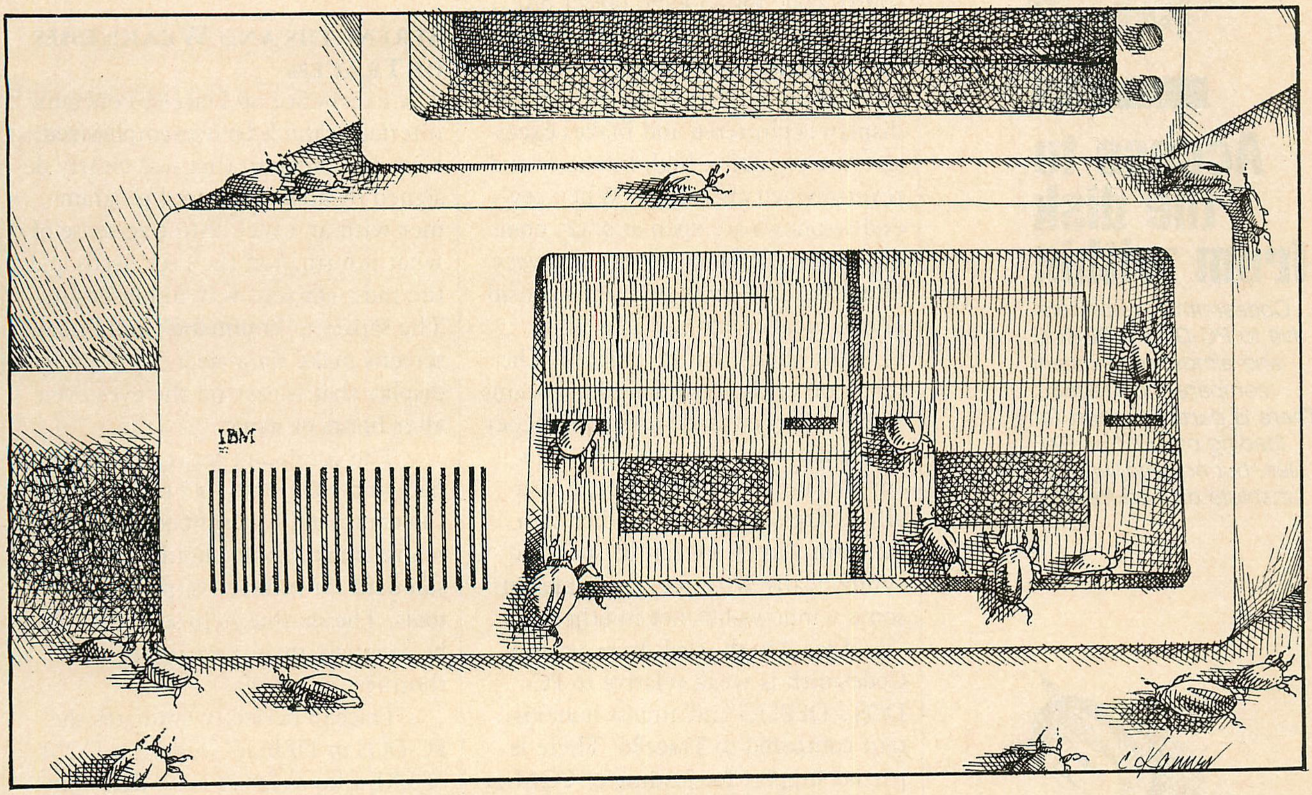
I then tried each program on three of my own utilities, each of which is fairly short but calls on some special feature of the PC's operating system. VMODE.COM calls the PC's ROM BIOS to set the video display mode according to a parameter 0-7, which is supplied in the command line. DISKTYPE.EXE reads the file-allocation table of a selected diskette and displays a message describing the format type. CLEAN.EXE exercises the new PC-DOS 2.0 file- and record-handling calls, while transforming a Wordstar document file into a normal ASCII text file that other editors (such as EDLIN or Volkswriter) can manipulate. Both Trace86 and Codesmith-86 handled these utilities well, including single-stepping through ROM. The files written by CLEAN under the control of each debugger were identical to those written by CLEAN when it is executing alone.

Next, as an acid test of each debugging utility's tolerance for complex behavior, I used them to trace the execution of one of my own company's products: the PC/FORTH interpreter/compiler. PC/FORTH contains an internal multi-tasker, accesses the 6845 video controller, writes text or graphics directly into the video refresh buffer, and takes over both the 1BH and 23H control/break interrupts, among other things. If a debugging utility can handle all that, it must be fairly bullet-proof.

Trace86 coped fairly well with the Forth interpreter/compiler. Although the displays occasionally got chaotic because of Trace86's inability to intercept the video output of the traced program, single-stepping and fast execution were performed properly. Trace86 never crashed except when I brought disaster on myself by overwriting a critical memory area or setting up registers incorrectly.

Codesmith-86 had more trouble with the Forth runtime system. The Screensave Mode (interception of video output from the traced program) worked well, but keyboard inputs directed to Forth intermittently caused Codesmith to arrest as though it had hit breakpoints buried deep in PC-

DOS. These mysterious stopping places were so far out in left field that the only practical response was to abort the tracing process. The multiple window handling also seemed to be overly fragile. Several times Codesmith wouldn't let me either move the cursor out of the current window or delete the window, finally necessitating a system reset.



Finally, I attempted two rather dire "tests to destruction" that I didn't really expect either program to pass. I first used both tools to load and execute COMMAND.COM, and then used Trace86 to trace Codesmith and Codesmith to load and execute Trace86. Codesmith crashed hopelessly on both tests, while Trace86, much to my surprise, did fairly well.

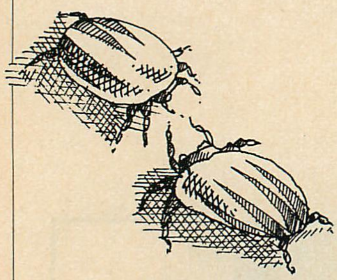
It should be noted that both Trace86 and Codesmith-86 properly fielded a breakpoint that was set within a control/break interrupt handler prior to a STI instruction or the issuing of the EOI (end-of-interrupt) command to the programmable interrupt controller. Anyone who has had the opportunity (or bad luck) to work with hardware interrupts on the 8088 will understand that this is a particularly vulnerable point in the execution of a handler. I fully expected one or the other program to bomb on this and so was duly impressed.

STRENGTHS AND WEAKNESSES OF CODESMITH-86

All in all, Codesmith-86 left me with a decidedly mixed impression. It incorporates several very powerful and novel features, including the multiple levels of windowing for memory dumps, the autodump link that automatically displays the context of a memory location referenced by a traced program, and the scrollable disassembly listing. The highly visual nature of the interaction makes finding, selecting, and setting breakpoints a breeze. The concept of a debugging configuration file has a lot of potential, though it currently allows only a few commands, none of which are exceptionally useful.

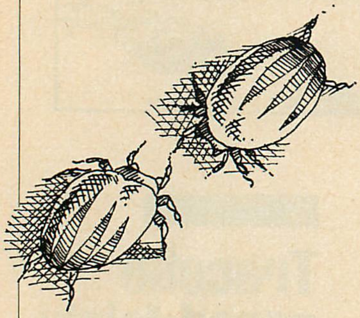
Codesmith's ability to capture video output by the traced program and place it in a separate "virtual" screen for viewing on demand, handling well even direct writes into the

Trace86 coped fairly well with *the Forth interpreter/compiler. Although the displays occasionally got chaotic because of Trace86's inability to intercept the video output of the traced program, single-stepping and fast execution were performed as they should have been.*



Access to the disk from within

Codesmith is weak relative to PC-DOS's DEBUG and almost nonexistent compared to Trace86. There is partial support for loading of COM or EXE files, but no read/write by absolute disk addresses.



video refresh buffer, is a distinct asset and should set a standard for all future products of this type.

Another unique feature is Codesmith's ability to write disassembled code, complete with comments supplied by the operator, into a disk file in a form that can be edited for reassembly. This makes recreation of source code for an alien object program relatively straightforward (given enough time and patience).

On the negative side, the screen display is cluttered and makes excessive use of jarring high-intensity and reverse-video characters. When several windows are open at once, none of them has enough room to be very effective. The command set is considerably weaker and not as well thought out as that of Trace86. The selection of the command keys seems rather arbitrary and lacks consistency and mnemonic value. There is no support for the 8087 coprocessor at all. Addresses are not handled in a uniform way; they can be specified symbolically with register names in some windows but not in others.

Access to the disk from within Codesmith is weak relative to PC-DOS's DEBUG and almost nonexistent compared to Trace86. There is partial support for loading of COM or EXE files, but no read/write by absolute disk addresses.

Finally, some outright flagrant bugs were encountered in Codesmith. When tracing a COM program, it does NOT exactly duplicate the initial register conditions specified in the DOS manual and followed by the PC-DOS DEBUG program. In fact, in one instance that could be readily duplicated (see photo 1), Codesmith initialized the Stack Pointer to contain an address within the Program Segment Prefix's default disk buffer, which quickly caused the destruction of the traced program's command tail and under other circumstances could damage data that was read into that buffer from the disk.

The "L" or "load file" command implements only part of the capabilities of DEBUG's "L" command and seems to have some fatal defects—it crashes the system when used more than once. The "N" command, to format the command line and file control blocks in the Program Segment Prefix, is supposed to be implemented in Codesmith but yields only spurious error messages.

STRENGTHS AND WEAKNESSES OF TRACE86

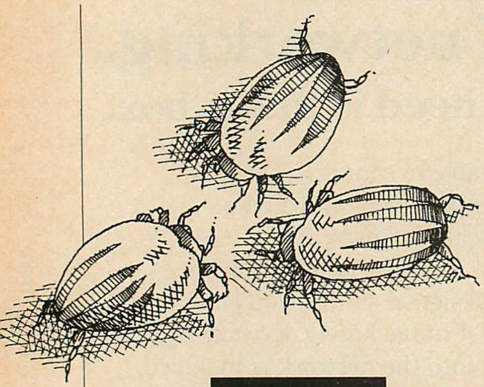
The excellence of Trace86's operator interface cannot be overemphasized. Here is a program that was clearly designed by an experienced programmer with an exact, intuitive sense of what information the user needs and the most efficient way to present it. The separate "command" and "trace" screens make for a clean, uncluttered display that is easy on the eyes even after hours of work.

The command set is rich, diversified, and coherent. As I noted before, the command-line syntax-checking is really amazing and should set a new standard for interactive program tools. The on-line help screens will be adequate to answer all but the thorniest questions.

Trace86 perfectly emulates the PC-DOS or DEBUG loader for COM or EXE files as far as I can determine. All registers and the program segment prefix are set up correctly. A zero word is pushed onto the stack for COM files before entry. Trace86 even supplies the path to the current subdirectory right behind the command tail in the default disk buffer at offset 80H; this is an "undocumented feature" of the PC-DOS loader and is another demonstration of Bennett's deep familiarity with the environment and attention to detail.

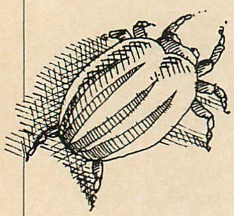
There is some primitive support for the 8087 coprocessor, with a command that permits the display of the static contents of the floating-point registers and other control information (strangely enough, however, the disassembly portion of Trace86 can't handle 8087 op-codes at all).

Disk-handling is very powerful



Trace86's lack of any facility

for interception of video output by the traced program makes it virtually useless for debugging graphics routines or any other program that builds complex screen displays.



and would be difficult to improve upon. Since different COM or EXE files can be loaded multiple times, it is possible to work on programs for long periods without ever leaving the debugging environment. As a disk utility, Trace86's commands to read, write, and modify physical disk sectors by drive, track, head, and sector provide most of the capabilities of PC-DOS's DEBUG and the Norton Utilities as a fringe benefit.

Trace86 does have a few deficiencies, though. Its lack of any facility for interception of video output by the traced program makes it virtually useless for debugging graphics routines or any other program that builds complex screen displays.

Also, Trace86 is capable of writing disassemblies into a disk file, but unlike Codesmith, it can't put them into a format suitable for reassembly. I haven't been able to decide if this is really bad: the most obvious use of this feature would probably be to steal other people's software anyway.

There is one last minor annoyance in Trace86. If the traced program resets the Stack Pointer from the value that was initially given to it, Trace86 fails to recognize what happened and tries to display a stack that is thousands of cells deep. This doesn't particularly affect the successful execution of a trace but is rather unsightly. I discussed this with the program's author, who explained that this problem is difficult to deal with in a truly general way. In the meantime, perhaps there should be an additional command to turn the stack display off in such situations.

SUMMARY

Tables 1 and 2 summarize and compare the main features of Codesmith and Trace86.

Trace86 is, in general, the best assembly language debugging tool I have ever encountered. Its design and implementation is totally professional. The command set is powerful, consistent, and flexible, providing nearly a complete operating system within an operating system. Displays are elegant, and screen updates are fast. Effective use on a large program requires a listing. A couple more years of evolution of this program, with the addition of a few missing features, would make it unbeatable.

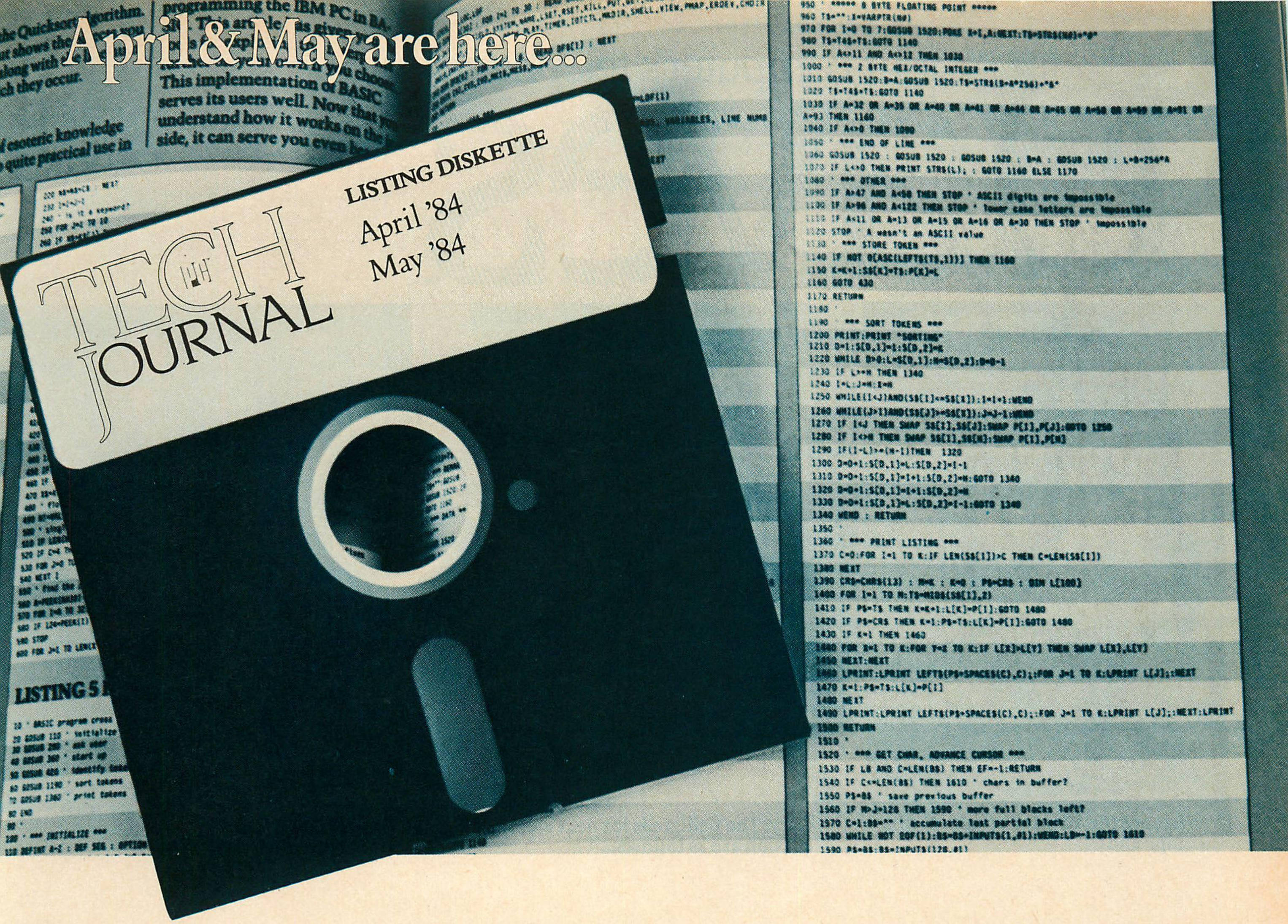
Codesmith's design seems to be slanted toward its use as a disassembly tool, for recreating source files from object programs. It can be used on a large program without the aid of a listing. Codesmith is currently superior to Trace86 for work on target programs performing extensive video output, but its lack of an adequate set of disk commands makes it a distinct second choice otherwise.

VITAL STATISTICS

Codesmith-86
Author: Erik Osborn
Version tested: 1.5.20
Disk space required: 125795 bytes in three files (with minimal configuration file)
RAM required: 192 kbytes minimum
Distributed by: Visual Age, Inc.
642 N. Larchmont Blvd.
Los Angeles, CA 90004
(213) 464-8141
Price: $145.00
CIRCLE 497 ON READER SERVICE CARD

Trace86
Author: Neil Bennett
Version tested: 1.09
Disk space required: 41344 bytes
RAM required: 128 kbytes minimum
Distributed by: Morgan Computing Company, Inc.
10400 North Central Expressway, Suite 210
Dallas, TX 75231
(214) 739-5895
Price: $125.00
CIRCLE 496 ON READER SERVICE CARD

Neither program is copy protected, and both programs will run on hard disk, and are compatible with either PC-DOS 1.1 or 2.0.



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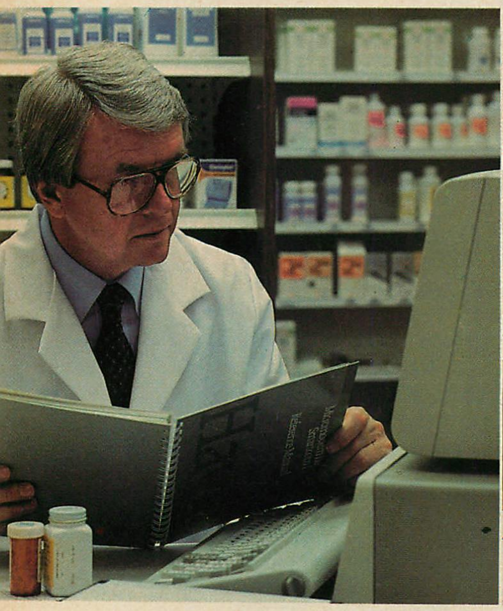

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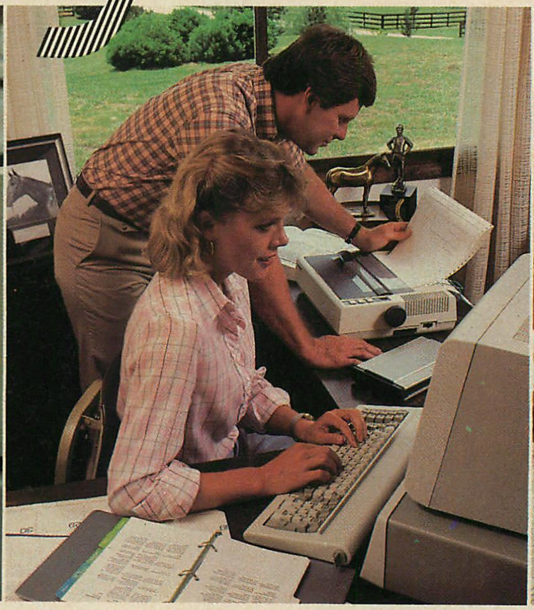

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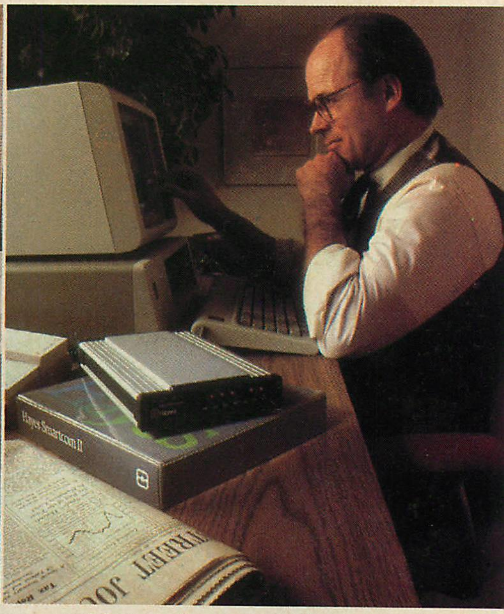

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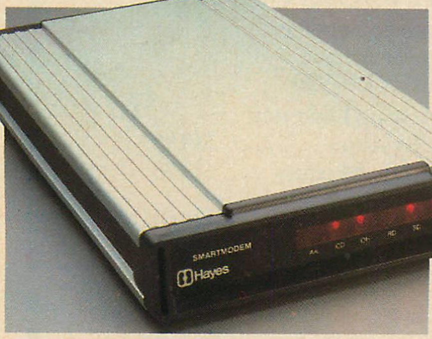

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Wish List

Programmers often dream of the capabilities they would most like to see in some programming tool. Here are some additional features that ought be included in the PC-DOS assembly language programmer's "ultimate debugging tool."

A really crucial deficiency in both Trace86 and Codesmith is the difficulty of manipulating the various parts of the Program Segment Prefix area. When tracing application software that gets its information via the command line, the programmer is currently forced by both programs to set these parameters up by entering the bytes one at a time. Even PC-DOS DEBUG does a better job of this, with the "N" command that automatically formats the default file-control blocks at offset 5CH and 6CH and the command tail buffer at offset 0080H. Trace86 and Codesmith ought to do even more. Perhaps we could have a set of commands like "ENVIR=," "FCB1=," "COMMANDTAIL=," etc.

Less crucial, but important in the long run, will be the tools' ability to handle PC-DOS 2.0 path names, "spawning" of "child" processes, and dynamic memory allocation. Trace86 already supports the last of these. Both companies have stated an intention to expand these capabilities.

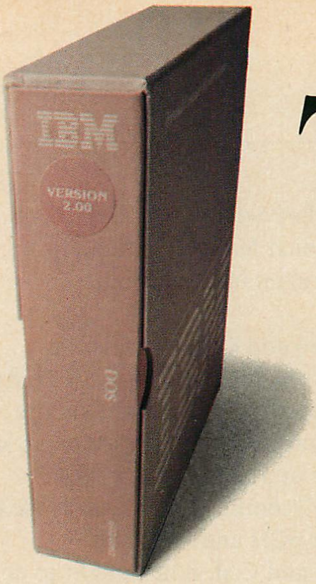
More powerful breakpoint capabilities would be nice. Engineers working with expensive development systems such as those sold by Gen-Rad or Tektronix take for granted the ability to set breakpoints on accesses to specific memory locations, I/O ports, and even on specific contents of memory or registers. In a similar vein, statistical and historical-reporting facilities would add a lot. What programmer faced with time-critical problems or weird program behavior hasn't wanted to know exactly where the CPU was spending most of its time? The program ZSID for Z-80 CP/M systems provided a histogram analysis of program execution years ago, so this shouldn't be too much to ask for the IBM PC.

Now that use of the 8087 is becoming widespread, more complete support for it is needed, including a dynamic display of the numeric processor's stack contents, control words, and status words, as well as assembly and disassembly of its instruction set.

A "calculator mode" that would handle complex expressions, such as register names, shifts, and logical operations, doesn't seem like much to ask. These programs are running on real computers, after all! The present ability to add and subtract hexadecimal numbers is better than nothing, but the old DDT program in CP/M-80 could do that seven years ago. It should be possible to type "(BX SHL 4) OR OFOFH AND 1010111100001111B" and instantly get the result.

The ability to access the symbol tables created by the Microsoft assembler would be wonderful. Reading in the table and associating the names in it with the relocated addresses of the program under test shouldn't be too difficult. Then it would be possible to really debug the program in a symbolic way, setting the registers and program counter with expressions that included names. Again, ZSID for CP/M-80 systems paved the way on micros with this capability years ago.

More farfetched (but memory is cheap these days) would be a trace/debugging utility that included all of the above and could perform the functions of the LINKER as well. A programmer could build programs up interactively out of OBJ modules fetched from individual files or from a library. This capability, in combination with an interactive assembler mode and the ability to use the symbol tables, would be a programmer's dream.



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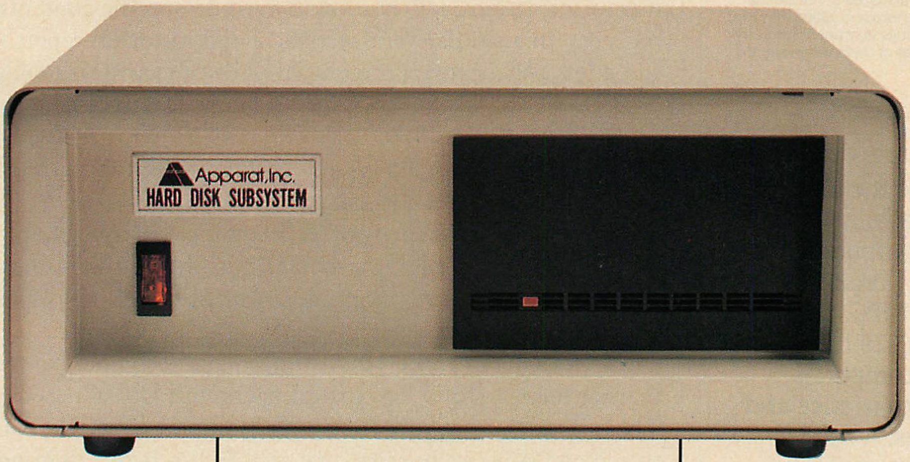

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Table 1:
Comparison of Commands in PC-DOS DEBUG and Those in Codesmith-86 and Trace86

DEBUG command	Codesmith-86	Trace86
A assemble interactively	absent	absent
C compare range of memory	absent	superior equivalent
D display memory	superior equivalent	superior equivalent
E enter data into memory	superior equivalent	superior equivalent
F fill memory	identical	superior equivalent
G execute with optional breakpoints	superior equivalent	superior equivalent
H hexadecimal arithmetic	identical	equivalent
I input data from port	identical	equivalent
L load file or absolute disk sectors	partial equivalent	superior equivalent
M move memory block	identical	superior equivalent
N define files and parameters for program segment prefix	absent	absent
O output data to port	identical	equivalent
Q terminate debug session	identical	identical
R display/set registers and flags	equivalent	superior equivalent
S search for characters	equivalent	superior equivalent
T execute and display	superior equivalent	superior equivalent
U disassemble instructions	superior equivalent	superior equivalent
W write file or absolute disk sectors	partial equivalent	superior equivalent

Table 2:
A Summary and Comparison of Significant Features of Codesmith-86 and Trace86

	Codesmith-86	Trace86
Breakpoints set	visually	by address
Syntax checking	line oriented global	character by character selective
"Fast mode" for execution of subroutines		
8087 support	None	Some
Dynamic display of stack	Yes	Yes
Read and write ports directly	Yes	Yes
Tracing in ROM	Yes	Yes
Traceback (display system state before last instruction executed)	Yes	Yes
Capture of traced program's output	Fairly good	None
Control code to finish only current loop or subroutine at full speed (without setting breakpoints)	No	Yes
Hex arithmetic	Rudimentary	Ditto
User-selectable display radix	Yes	No
Uniform handling of symbolic addresses	No	Yes
Memory dump of selected areas in hex and ASCII	Yes	Yes
Automatic dump of memory locations accessed by traced program	Yes	No
"Windowed" memory dump	Yes	No
Control over memory dump format	None	Extensive
Formatted memory dump directed to disk file	No	Yes
Copy specified area of memory to file or vice versa	No	Yes
Scroll through disassembly without executing	Yes	No
Add comments to disassembled listing	Yes	No
Dump disassembly into file	Yes	Yes
Disassembly to disk suitable for reassembly (with some editing)	Yes	No
Load EXE or COM programs from within trace utility	Present but defective	Yes
Direct disk access by drive track, head, and sector	No	Yes
On-line help menus	No	Yes
Demo supplied	Yes	Yes
Sample programs with detailed tracing instructions supplied	No	Yes
Support for trace configuration files on disk	Weak	None
Printer support in trace mode	No	Yes
Color monitor support	Gaudy	Works ok
Support for DOS 2.0 paths etc.	No	No
Support for DOS 2.0 memory allocation by traced program	No	Yes
Interactive assembly	No	No
Convenient entry of traced program's PSP parameters	No	No

Listing 1 An excerpt from the original program listing for VMODE. Compare this with the debugging utilities' disassemblies in figures 1, 2, and 4, and with listings 2-4.

```
0100              vmode:                    ;initialize DI to the
                                            ;address of the input buffer
0100  BF 0080          mov    di,offset input
0103  8A 05            mov    al,[di]       ;check if any command tail
0105  0A C0            or     al,al         ;and exit if not
0107  74 40            jz     vmode7
0109  B0 20            mov    al,blank      ;load ASCII blank for scan
010B  47               inc    di            ;increment address in DI
                                            ;past the input count byte
010C  B9 0050          mov    cx,80         ;scan max of 80 chars.
010F  FC               cld                  ;clear direction flag
0110  F3/ AE           repz scasb           ;look for first none-blank
                                            ;character in input buffer
0112  74 35            jz     vmode7        ;jump if none found
                                            ;load the none-blank char.,
                                            ;use offset of -1 since DI
                                            ;will be pointing past it
0114  8A 45 FF         mov    al,-1 [di]
0117  3C 0D            cmp    al,cr         ;if first none-blank char
                                            ;was RETURN,mode was missing
0119  74 2E            jz     vmode7        ;so go print error message
011B  3C 30            cmp    al,'0'        ;make sure it is range 0-7
011D  72 2F            jb     vmode8        ;exit if ASCII code < '0'
011F  3C 37            cmp    al,'7'
0121  77 2B            ja     vmode8        ;exit if ASCII code > '7'
0123  A2 016B R        mov    vmodeb,al     ;store mode number into
                                            ;output string
0126  24 0F            and    al,0fh        ;mask off upper four bits
                                            ;of char. to get 0-7
0128  50               push   ax            ;save mode for later
0129  33 DB            xor    bx,bx         ;set ES=zero
```

Listing 2 Disassembly to disk file in "normal format" by Codesmith-86. Same code fragment as listing 1.

```
2A64:0100  BF8000              MOV    DI,0080H
2A64:0103  8A05                MOV    AL,[DI]
2A64:0105  0AC0                OR     AL,AL
2A64:0107  7440                JE     0149H
2A64:0109  B020                MOV    AL,20H
2A64:010B  47                  INC    DI
2A64:010C  B95000              MOV    CX,0050H
2A64:010F  FC                  CLD
2A64:0110  F3AE         REPZ   SCASB
2A64:0112  7435                JE     0149H
2A64:0114  8A45FF              MOV    AL,0FFH[DI]
2A64:0117  3C0D                CMP    AL,0DH
2A64:0119  742E                JE     0149H
2A64:011B  3C30                CMP    AL,30H
2A64:011D  722F                JC     014EH
2A64:011F  3C37                CMP    AL,37H
2A64:0121  772B                JA     014EH
2A64:0123  A26B01              MOV    [016BH],AL
2A64:0126  240F                AND    AL,0FH
2A64:0128  50                  PUSH   AX
2A64:0129  33DB                XOR    BX,BX
```

Listing 3 Disassembly to disk file by Codesmith, in special format suitable for editing into a standard assembly language source file. Same code fragment as listing 1.

```
MOV     DI,0080H              MOV     AL,20H
MOV     AL,[DI]               INC     DI
OR      AL,AL                 MOV     CX,0050H
JE      $ + 0042H             CLD
```

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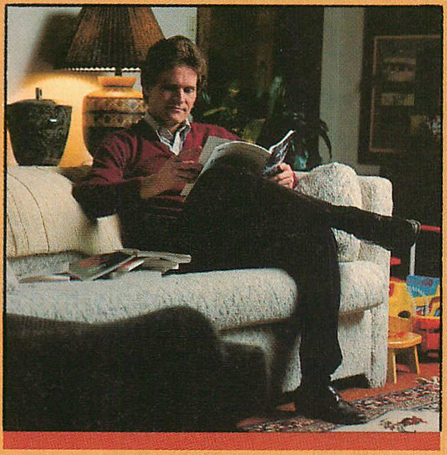
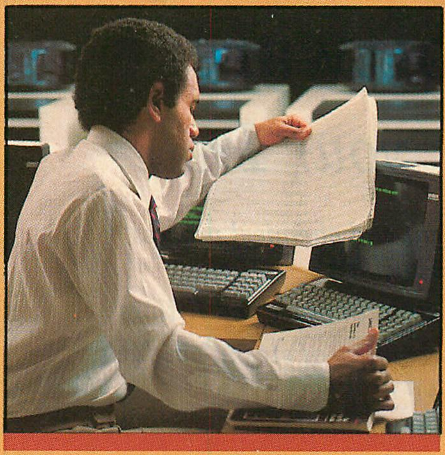
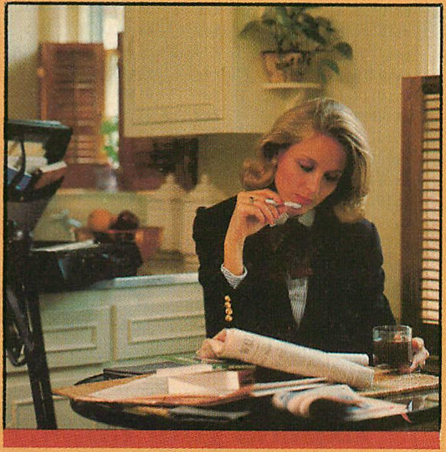
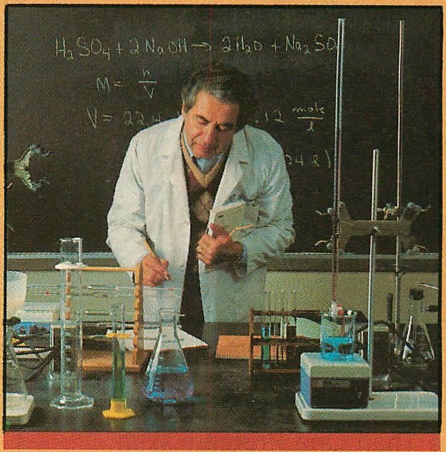

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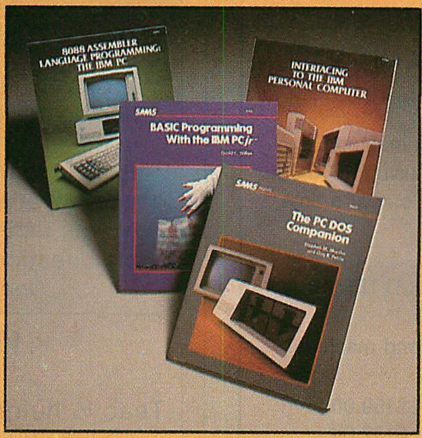

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```
REPZ   SCASB
       JE      $ + 0037H
       MOV     AL,OFFH[DI]
       CMP     AL,ODH
       JE      $ + 0030H
       CMP     AL,30H
       JC      $ + 0031H
       CMP     AL,37H
       JA      $ + 002DH
       MOV     [016BH],AL
       AND     AL,OFH
       PUSH    AX
       XOR     BX,BX
```

Listing 4 Disassembly to disk file by Trace86. Same fragment as listing 1.

```
cs:0100 bf8000      mov      di,0080
cs:0103 8a05        mov    b al,[di]
cs:0105 0ac0        or       al,al
cs:0107 7440        je       0149
cs:0109 b020        mov      al,20
cs:010b 47          inc      di
cs:010c b95000      mov      cx,0050
cs:010f fc          cld
cs:0110 f3ae        repe     scasb
cs:0112 7435        je       0149
cs:0114 8a45ff      mov    b al,[ff+di]
cs:0117 3c0d        cmp      al,0d
cs:0119 742e        je       0149
cs:011b 3c30        cmp      al,30
cs:011d 722f        jb       014e
cs:011f 3c37        cmp      al,37
cs:0121 772b        jnbe     014e
cs:0123 a26b01      mov    b [016b],al
cs:0126 240f        and      al,0f
cs:0128 50          push     ax
cs:0129 33db        xor      bx,bx
```

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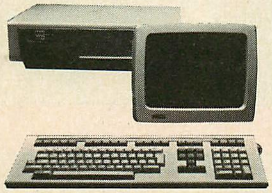

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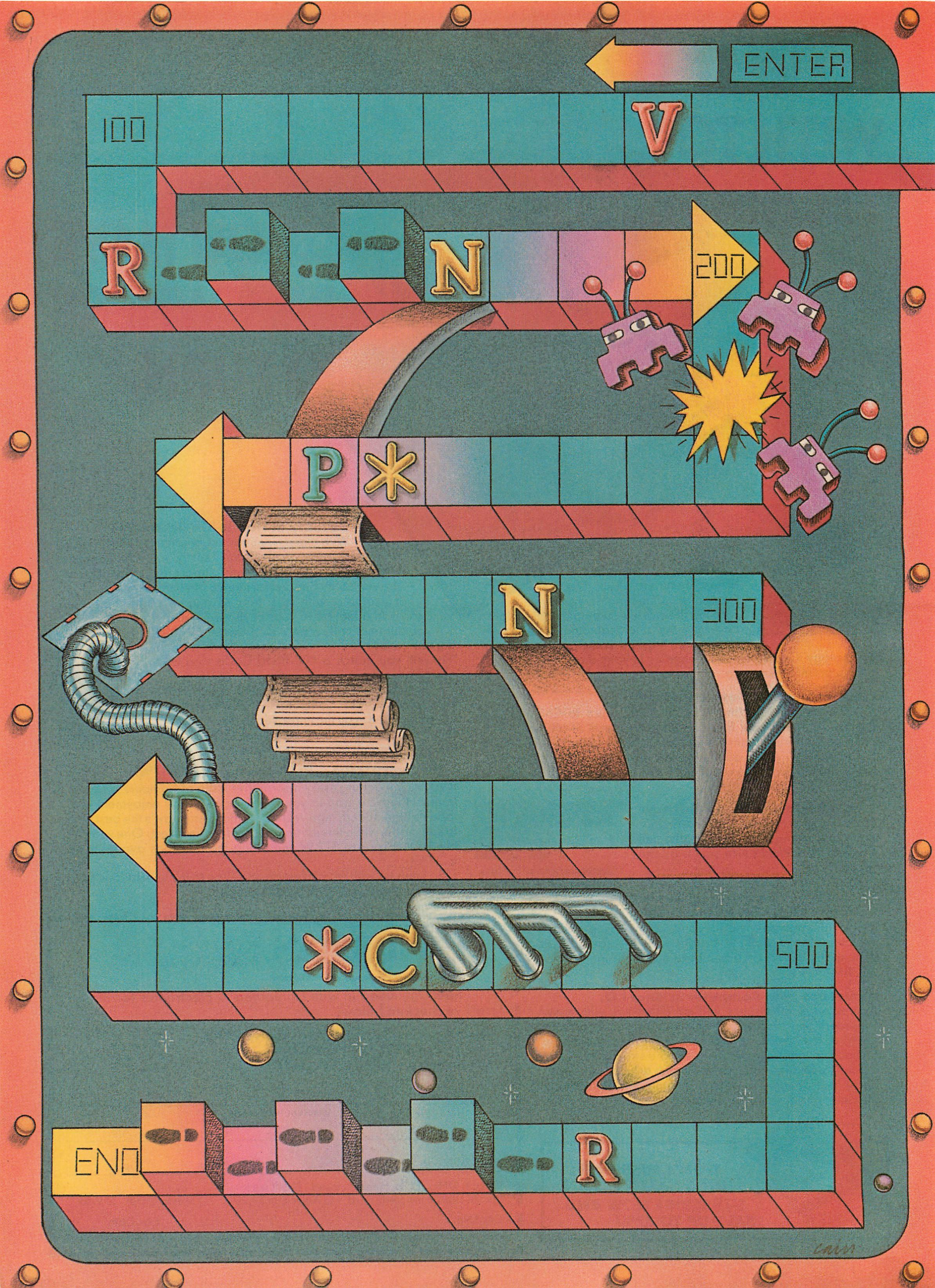

ENTER
100
V
R
N
200
P*
N
300
D*
*C
500
R
END
cain

Single-Stepping and Tracing

A simple program called TRACE that helps debug BASIC programs

D. Z. KORKUT

Programmers often want to trace BASIC programs without losing the result of the trace, which they can't necessarily do with the TRON command. They also often want to single-step through a program, observing the values of variables. There are currently no commands that allow single-stepping. What's a programmer to do? Try TRACE.

TRACE is a simple BASIC program that reads an ASCII version of a program. It then produces a version of the program with trace statements inserted between lines. This trace version allows the programmer to:

1. Single-step using the space bar
2. Print the trace using a line printer
3. Print the trace on a disk to be viewed with an editor
4. Specify where the trace is to start and end
5. Specify variable names to be traced.

When TRACE reads a line of the input program, it determines the line number and then writes that line, plus an extra line, to the output file. The extra line contains a trace statement, which consists of a variable-assignment statement that stores the line number in a variable, and a GOSUB statement, which jumps to a subroutine that TRACE appends to the end of the output program file. The subroutine contains code that interprets commands issued while running the trace version of the program. The program file is not modified.

RUNNING TRACE

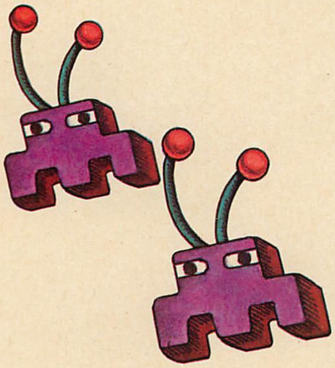
TRACE produces an executable BASIC program, so there are some limitations involved. The first thing TRACE will do is to remind the user of these limitations:

1. Since TRACE will insert lines between the lines of the program, it is important that the program be renumbered such that there is at least one vacant line number between each line. TRACE also appends a small module to the beginning and end of the program, so no line numbers less than 10 or greater than 59999 can be used. I recommend that the command RENUM 10,5 be used.
2. Remember to save the program in ASCII format. This is important.
3. The trace version of the program will use two disk files. Remember to initialize BASIC with enough file buffer memory to handle the program's files plus two extra files.
4. The modules that TRACE appends use variable names with two trailing periods (i.e., <name>..). Avoid using this form elsewhere.
5. Do not use the CLOSE statement in the program without specifying

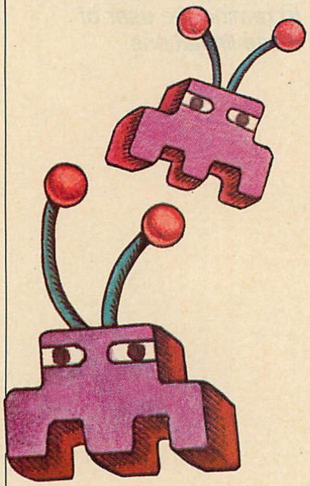
TRACE produces an executable *BASIC program, so there are some limitations. The first thing TRACE will do is to remind the user of these limitations.*

D. Z. Korkut is head of software development for Korkut Engineers, Inc. in Metairie, Louisiana.

ILLUSTRATIONS • DAVID CAIN



After the first two prompts are *answered, the trace version of the program will execute normally until a trace statement is found.*



a file number; doing so will cause the files required by the trace modules to be closed.

After confirming that these requirements have been met, TRACE will ask some questions. The user must enter the last file number used by his program, so TRACE will know which file numbers to use. A null entry will be assumed to mean that the program does not use files. Next, the drive where the program file resides must be entered. The trace version of the program will be written on this drive. A null entry will be assumed to mean drive B.

Enter the file name of the program next, including an extension if desired. If no extension is provided, one of .BAS is assumed. Then enter the line where trace statements should start. Since for large programs the overhead created by TRACE will be large, it may be desirable to insert trace statements only on a fixed range of statements. A null entry will be taken to mean that trace statements should start at the first line of the program. After this, enter the line where trace statements should stop. A null entry will be assumed to mean that trace statements should stop at the end of the program.

Next, TRACE will list each line of the program file. An "*" will appear after each line number where a trace statement has been added. When the list is finished, TRACE will ask if the user wishes to run the trace version of the program. If the user says yes, the trace version will automatically be loaded and executed. If the user elects to run the trace version later, it is stored with the same file name of the input program, but with an extension of .DBG.

COMMANDS AVAILABLE WHILE RUNNING A TRACED PROGRAM

When the trace version of the program is executed, the user must first enter where tracing should begin and end. If trace statements have been added to every line of the program, every line may be traced selectively, one block at a time. If, because of lack of memory, trace statements were inserted on only part of the program, any block of statements in that part may be traced. For example, if a user decided to insert trace statements beginning with line 1000 and ending with line 5000, when he ran the trace version of the program he could selectively trace any block of statements between lines 1000 and 5000 inclusive. A null entry to these first two prompts will be assumed to mean that all lines should be traced with trace statements.

After the first two prompts are answered, the trace version of the program will execute normally until a trace statement is encountered. It will then display, in brackets, the number of the line that was just executed, after which it will pause, waiting for one of these commands:

<space bar> – single-step to the next statement

D – single-step to the next statement and start dumping the trace to a file named TRACE.DBG. The line numbers displayed on the CRT will now be dumped to the disk file beginning with the current line. Line numbers oon the CRT will displayed with a "D*" prefix. This is to remind the user that the trace is dumping to the disk.

P – single-step to the next statement and start dumping the trace to the line printer. The line numbers displayed on the CRT will now be printed on the line printer. Line numbers on the CRT will be displayed with a P* prefix as a reminder that the trace is dumping to the line printer. If TRACE is currently dumping to the disk the disk file will be closed.

(NOTE: It is impossible to dump to the disk and to the printer at once.)

V – display values of those variables chosen with the C command. If the trace is dumping to the disk or line printer, the variable values will also

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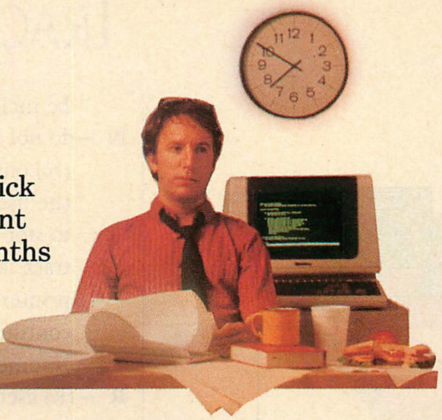

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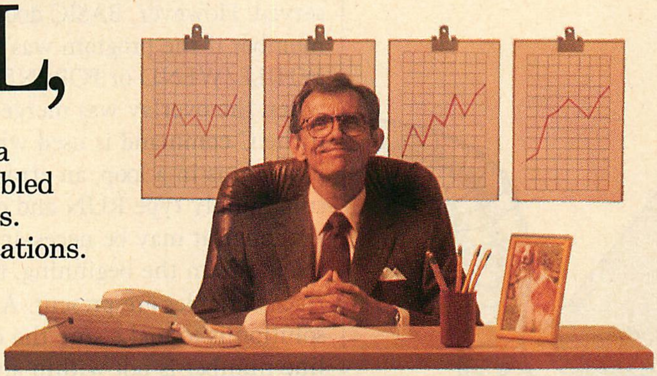

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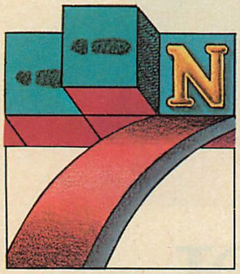


Remember that the trace version *of the program is a BASIC program; CTRL-BREAK can be used to halt execution at any time.*

be included.

N – do not single-step; instead, execute (N) onstop. While running nonstop, the user can press the <space bar> to stop and start execution. If the trace is dumping to the disk or line printer, the dump will still continue. Use the R command to resume single-stepping.

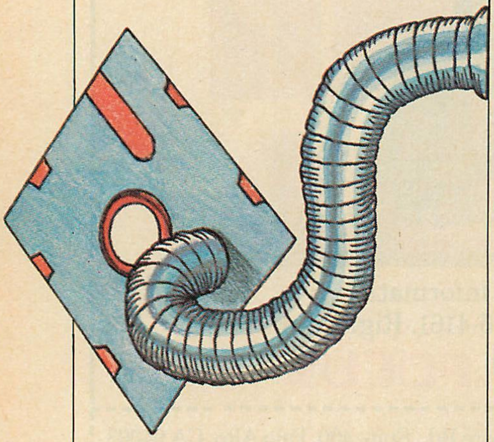
R – (R) esets the D, P, V, and N commands, All dumping of the trace to the disk and line printer will halt. Variable values will no longer be shown on the CRT. If the program is running nonstop, single-stepping will resume.

T – allows the user to change the block of statements currently being traced. This does not affect any other command.

C – allows the user to (C)hange the variables that will be traced. Variable names should be entered one at a time. If a null variable name is entered, tracing will continue. The V command can then be used to begin tracing the new variables.

One word of caution: the C command creates an overlay module that is CHAIN MERGEd into the traced program. All variable values are preserved. However, BASIC does not remember if the program was in a WHILE/WEND or FOR/NEXT loop when the overlay was merged. Thus, if the C command is used while the program is in a loop, an error may result. Simply type RUN and continue. Although it may be necessary to start tracing from the beginning, the new trace variables are present. A simpler solution is to make sure the current line number is not within any loops before using the C command.

Remember that the trace version of the program is a standard BASIC program; CTRL-BREAK can be used to halt execution at any time.



RECOMMENDED PROCEDURE FOR DEBUGGING To use TRACE as a debugging aid, begin by RENUMbering the program beginning with line 10 and using an increment of at least two. Then SAVE the program using the A option, LLIST the program so that it is always clear where execution is currently taking place, and decide (based on the program's length) which parts of the program need to be traced.

It is helpful in judging how many lines to trace to know the approximate overhead required by a traced program. It is as follows:

overhead = 2080 + *l19 + *v**50 bytes**

where *l* equals the number of lines to which trace statements should be added, and *v* equals the number of variables to be traced. Thus a 100-line program with all lines and 10 variables traced needs about 4480 extra bytes in the trace version.

After deciding how much of the program to trace, run TRACE, answering the questions according to the guidelines above. Then execute the trace version, being careful to change traced variables only while outside any loops. Use the trace commands to perform any debugging and CTRL-BREAK and EDIT to make any changes; note any such changes on the program listing.

Next, reload the original program and post all changes made while debugging. If the trace requires much output, use the D command to dump it to a disk file. Then use EDLIN in conjunction with the program listing to review the result of the trace.

TRACE was written using the RATBAS translator (see *PC Magazine*, vol. 1, no. 6, p. 121). The listing given is in standard IBM PC BASIC, generated by the translator, which is, by the way, a great piece of software.

Using TRACE, programmers will find it easier to trace BASIC programs and to single-step through programs while observing the values of the variables. This should result in better programs, achieved less painfully.

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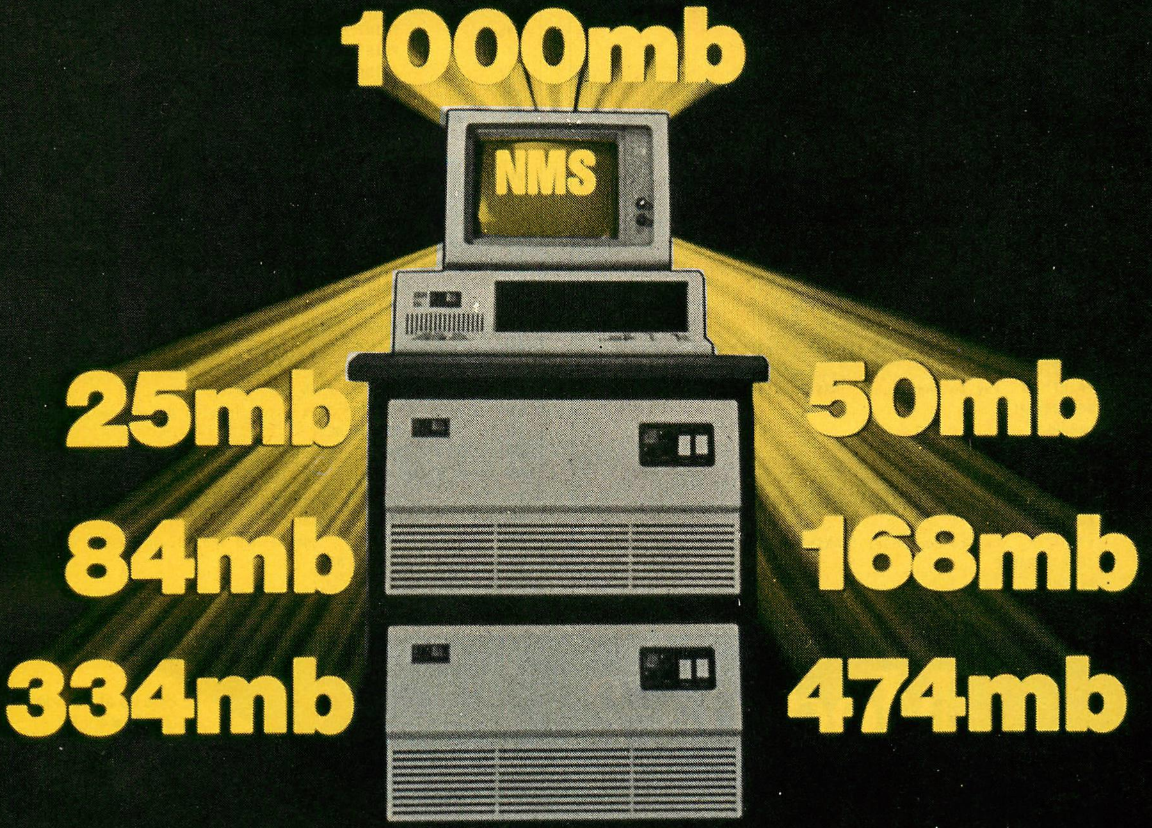

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Listing 1 TRACE.BAS

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105     ' ********* BASIC version of RatBas program **********
110      DEFINT I-N
180     '
185     GOTO 25000 ' jump to program
200     '---------------------- PROCEDURE ERROR
205     '
210     '  This procedure handles errors, including operator input error
215     '
220       IERROR=TRUE
225       SOUND 800,20
230       PRINT
235       COLOR 23,0
240       PRINT "E";
245       COLOR 7,0
250     ' CASE  ERR  OF
255     IF ( ERR =13)  THEN ELSE GOTO   280
260             PRINT"* You have entered an invalid character, please";
263        PRINT" check"
265             PRINT"     your entry."
270             RESUME NEXT
275     GOTO   575
280     IF ( ERR =24)  THEN ELSE GOTO   310
285             PRINT"* The printer is unavailable, Please check and";
287             PRINT"press any "
290             PRINT"     key to continue: ":AN$=INPUT$(1)
295             IERROR=FALSE
300             RESUME
305     GOTO   575
310     IF ( ERR =27)  THEN ELSE GOTO   340
315             PRINT"* The printer is out of paper, Please check and";
317             PRINT"press any "
320             PRINT"     key to continue: ":AN$=INPUT$(1)
325             IERROR=FALSE
330             RESUME
335     GOTO   575
340     IF ( ERR =53)  THEN ELSE GOTO   360
345             PRINT"* File does not currently exist"
350             RESUME NEXT
355     GOTO   575
360     IF ( ERR =55)  THEN ELSE GOTO   380
365             PRINT"* File is already open, processing halted."
370             END
375     GOTO   575
380     IF ( ERR =61)  THEN ELSE GOTO   405
385             PRINT"* Disk is full, insert new formated disk and";
387             PRINT" re-run program."
390             PRINT"     Processing halted."
395             END
400     GOTO   575
405     IF ( ERR =67)  THEN ELSE GOTO   435
410             PRINT"* Too many files are on the disk."
415             PRINT"     Insert new formated disk and re-run program."
420             PRINT"     Processing halted."
425             END
430     GOTO   575
435     IF ( ERR =71)  THEN ELSE GOTO   465
440             PRINT"* The disk drive door is open, please close."
445             PRINT"     Press any key when ready. ":AN$=INPUT$(1)
450             IERROR=FALSE
455             RESUME
460     GOTO   575
465     IF ( ERR =200)  THEN ELSE GOTO   485
470             PRINT"* This is an invalid drive spec, please re-enter."
475             RESUME NEXT
480     GOTO   575
485     IF ( ERR =201)  THEN ELSE GOTO   510
490             PRINT"* This is an invalid filenumber, please enter a";
493             PRINT" number."
495             PRINT"     between 0 and 13, inclusive"
500             RESUME NEXT
505     GOTO   575
```

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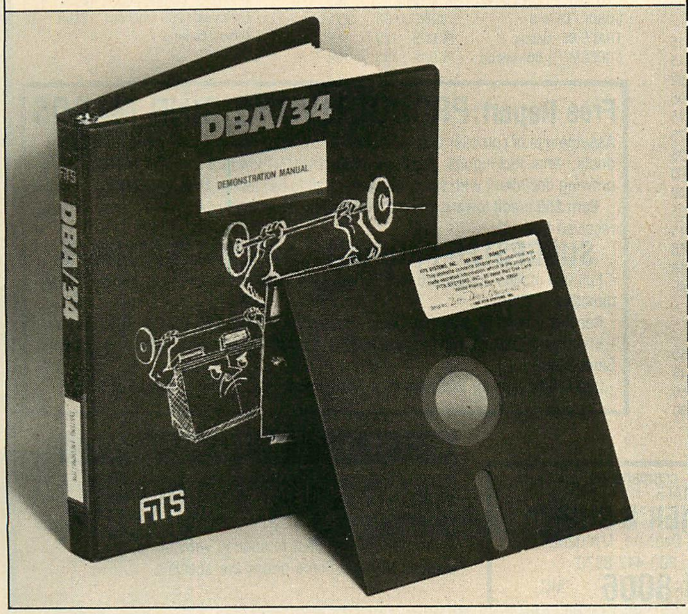

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```
510     IF ( ERR =202)  THEN ELSE GOTO    530
515             PRINT"* You have already specified a disk drive, please";
517             PRINT" re-enter."
520             RESUME NEXT
525     GOTO    575
530     IF ( ERR =203)  THEN ELSE GOTO    555
535             PRINT"* This is an ivalid NUMBER, please enter a number";
537             PRINT" between"
540             PRINT"        10 and 59999, inclusive."
545             RESUME NEXT
550     GOTO    575
555     ' OTHERWISE
560             PRINT"* An unexpected error #";ERR;" has occurred in";
563             PRINT" line #";ERL;"."
565             PRINT"        Processing halted."
570             END
575     ' CEND
580     RESUME NEXT ' --------------------
24531         IF LEN(DRV$)=2 THEN DRV$=LEFT$(DRV$,1)
25000     ' ================== PROCEDURE LOCATIONS ===========
25005     '  200 ERROR
25010     ' ================= PROGRAM =======================
25015     FALSE = 0: TRUE = NOT FALSE
25020     ON ERROR GOTO  200
25025     '
25030     '  Constants:
25035     '
25040       DEFAULT.DRV$="B"
25045       DEFAULT.FILENAME$="DTEST"
25050       DEFAULT.EXT$="BAS"
25055       DEFAULT.FIRST=10
25060       DEFAULT.LAST!=59999!
25065       EOL$=CHR$(13)+CHR$(10)
25070     '
25075     '  Logo
25080     '
25085       CLS
25090       KEY OFF
25095       LOCATE 4,24
25100       COLOR 0,7
25105       PRINT " Single Step and Trace Facility "
25110       COLOR 7,0
25115       LOCATE 6,38
25120       PRINT "by"
25125       LOCATE 8,34
25130       PRINT "D. Z. Korkut"
25135       LOCATE 10,33
25140       PRINT "version 1.1"
25145       FOR I=1 TO 10000
25150       NEXT
25155       CLS
25160     '
25165     '  Ask about the program to be traced
25170     '
25175       LOCATE 2,25
25180       COLOR 0,7
25185       PRINT" *** IMPORTANT *** "
25190       COLOR 7,0
25195       LOCATE 5,1
25200       PRINT"1)  Have you renumbered the program to be traced so";
25201       PRINT" that all line"
25205       PRINT"     numbers are between 10 and 59999, inclusive?"
25210       PRINT
25215       PRINT"2)  Is there at least one vacant line number between";
25216       PRINT" each line"
25220       PRINT"     (i.e. did you use an increment of at least 2 when";
25221       PRINT" renumbering)?"
25225       PRINT
25230       PRINT"3)  Did you save the program to be traced in ASCII";
25231       PRINT" format?"
25235       PRINT
25240       PRINT"4)  If there are <n> files in the program to be";
25241       PRINT" traced, did you "
25245       PRINT"     initialize BASIC with enough memory for <n+2>";
25246       PRINT" files?"
25250       PRINT
25255       PRINT"5)  Does the program to be traced have any variables";
25256       PRINT" of the form"
```

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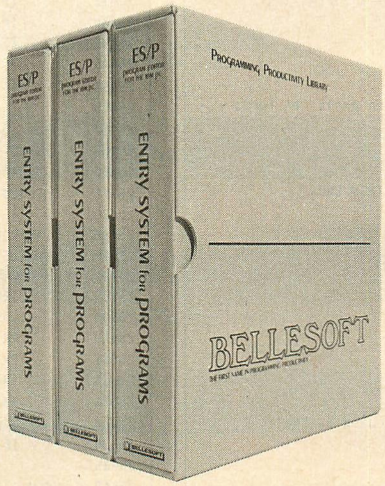

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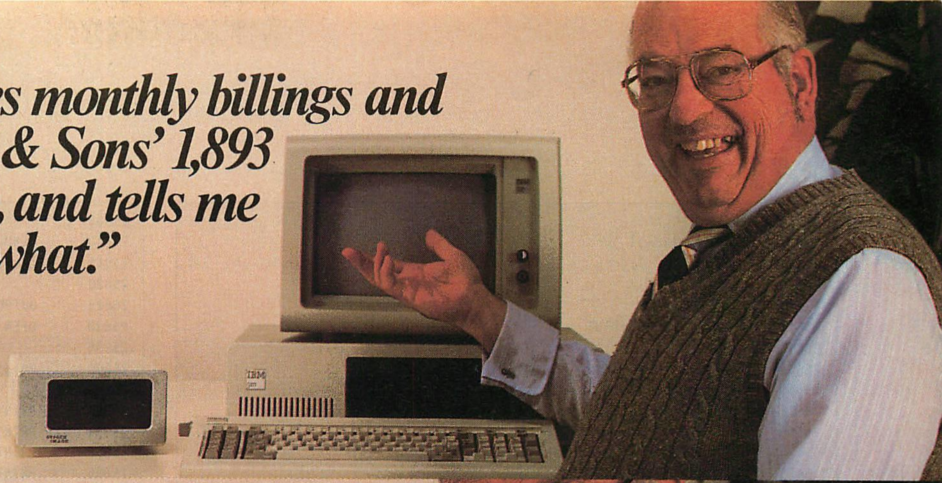
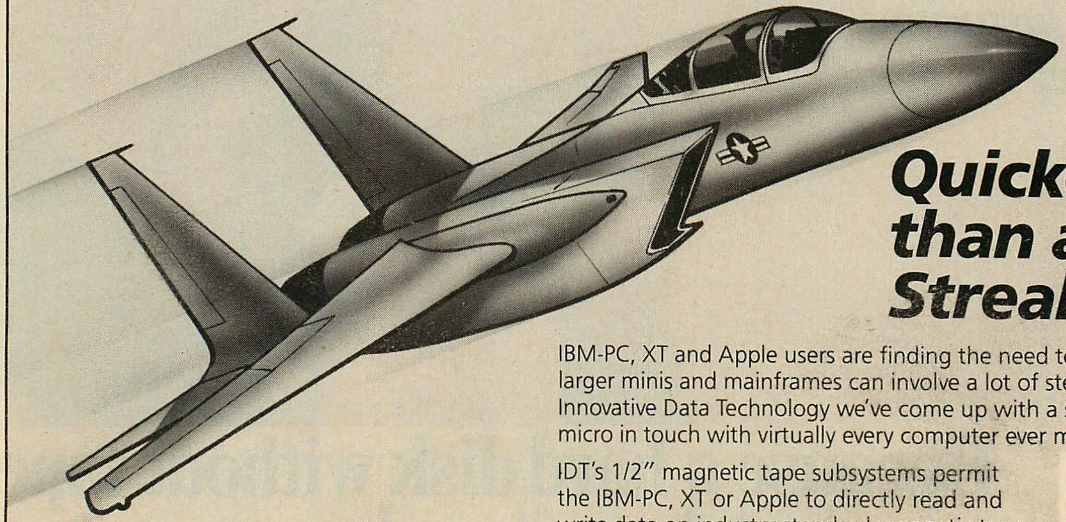
```
25260     PRINT"    <vname>.. (i.e. variable names with 2 trailing";
25261     PRINT" periods)? If so,"
25265     PRINT"    change them."
25270     PRINT
25275     PRINT
25280     PRINT"If you have not done these items, then press 'e' for";
25281     PRINT" exit else press"
25285     PRINT"     any other key to continue: ";
25290     ANS$=INPUT$(1)
25295     IF LEFT$(ANS$,1)="e" OR LEFT$(ANS$,1)="E" THEN END
25300     CLS
25305  '
25310  '  Operator entry
25315  '
25320     LOCATE 12,1
25325     IERROR=TRUE
25330     WHILE IERROR=TRUE
25335        CLS
25340        IERROR=FALSE
25345        LOCATE 12,10
25350        PRINT"Please enter the last file number used by the";
25351        PRINT" program to be"
25355        LOCATE 13,10
25360        INPUT"     traced: ",FILENO$
25365        FILENO%=VAL(FILENO$)
25370        IF FILENO%<0 OR FILENO%>13  THEN ELSE GOTO  25390
25375           ERROR 201
25380           FOR I=1 TO 10000
25385           NEXT
25390         ' IFEnd]
25395     WEND
25400  '
25405     IERROR=TRUE
25410     WHILE IERROR=TRUE
25415        CLS
25420        IERROR=FALSE
25425        LOCATE 12,10
25430        PRINT"Please enter the drive where files will be read";
25431        INPUT" and written: ",DRV$
25432        IF LEN(DRV$)=2 THEN DRV$=LEFT$(DRV$,1)
25435        IF DRV$="" THEN DRV$=DEFAULT.DRV$
25440        IF INSTR("abcdABCD",LEFT$(DRV$,1))=0  THEN ELSE GOTO 25460
25445           ERROR 200
25450           FOR I=1 TO 10000
25455           NEXT
25460         ' IFEnd]
25465     WEND
25470     FLN$=STR$(FILENO%+1)
25475     FLN2$=STR$(FILENO%+2)
25480
25485     IERROR=TRUE
25490     WHILE IERROR=TRUE
25495        CLS
25500        IERROR=FALSE
25505        LOCATE 12,10
25510        PRINT"Please enter the filename (and extension if you";
25511        PRINT" wish) of"
25515        INPUT"     the program file you wish to trace: ",ANS$
25520        ANS$=LEFT$(ANS$,12)
25525        DELIMIT%=INSTR(ANS$,".")
25530        IF INSTR(ANS$,":")<>0  THEN ELSE GOTO  25545
25535           ERROR 202
25540   GOTO   25605
25545 ' ELSE]
25550   IF DELIMIT%=0  THEN ELSE GOTO  25570
25555   IF ANS$="" THEN FILENAME$=DEFAULT.FILENAME$ ELSE FILENAME$=ANS$
25560   EXT$=DEFAULT.EXT$
25565   GOTO   25590
25570   ' ELSE]
25575              FILENAME$=LEFT$(ANS$,DELIMIT%-1)
25580              EXT$=RIGHT$(ANS$,LEN(ANS$)-DELIMIT%)
25585              EXT$=LEFT$(EXT$,3)
25590            ' IFEnd]
25595           INPUT.FILESPEC$=DRV$+":"+FILENAME$+"."+EXT$
25600           OPEN INPUT.FILESPEC$ FOR INPUT AS #1
25605         ' IFEnd]
25610        IF IERROR=TRUE  THEN ELSE GOTO  25625
25615           FOR I=1 TO 10000
```



```
25620          NEXT
25625        ' IFEnd]
25630     WEND
25635     '
25640     IERROR=TRUE
25645     WHILE IERROR=TRUE
25650        CLS
25655        IERROR=FALSE
25660        LOCATE 12,10
25665        PRINT"Please enter the line of the program to be traced";
25666        PRINT" where you want"
25670        INPUT"     debug statements to start: ",FIRST$
25675        FIRST=VAL(FIRST$)
25680        IF IERROR=FALSE  THEN ELSE GOTO  25715
25685           IF FIRST=0 THEN FIRST=DEFAULT.FIRST
25690           IF FIRST<10 OR FIRST>59999!  THEN ELSE GOTO  25710
25695              ERROR 203
25700              FOR I=1 TO 10000
25705              NEXT I
25710            ' IFEnd]
25715         ' IFEnd]
25720     WEND
25725     '
25730     IERROR=TRUE
25735     WHILE IERROR=TRUE
25740        CLS
25745        IERROR=FALSE
25750        LOCATE 12,10
25755        PRINT"Please enter the line of the program to be traced";
25756        PRINT" where you want"
25760        INPUT"     debug statements to end: ",LAST$
25765        LAST!=VAL(LAST$)
25770        IF IERROR=FALSE  THEN ELSE GOTO  25805
25775           IF LAST!=0 THEN LAST!=DEFAULT.LAST!
25780           IF LAST!<10 OR LAST!>59999!  THEN ELSE GOTO  25800
25785                ERROR 203
25790                FOR I=1 TO 10000
25795                NEXT I
25800             ' IFEnd]
25805        ' IFEnd]
25810     WEND
25815     IF FIRST>LAST! THEN SWAP FIRST,LAST!
25820  '
25825     OUTPUT.FILESPEC$=DRV$+":"+FILENAME$+"."+"DBG"
25830     OPEN OUTPUT.FILESPEC$ FOR OUTPUT AS #2
25835  '
25840  '  Print the first line in the debug version
25845  '
25850     PRINT #2,"1 cls:key off:open ";CHR$(34);DRV$;":";"trace.dbg";
25851     PRINT CHR$(34);
25855     PRINT #2,"for output as #";FLN$;":pr..%=0:pr..$=";CHR$(34);
25856     PRINT CHR$(34);
25860     PRINT #2,":ns..%=0:vs..%=0:eol..$=chr$(13)+chr$(10)";EOL$;
25865  '
25870  '  Record the range where debug statements exist in output file
25875  '
25880     PRINT #2,"2 first..!=";FIRST;":last..!=";LAST!;EOL$;
25885  '
25890  '  Ask for the trace range
25895  '
25900     PRINT #2,"3 gosub 63010"
25905  '
25910     PRINT #2,"5 '  ************* BEGIN DEBUG *************";EOL$;
25915  '
25920  '  Read each line of the input file, derive the line number
25925  '     and write to the output file
25930  '
25935     CLS
25940     WHILE NOT EOF(1)
25945        LINE INPUT#1,TEXT$
25950        PRINT #2,TEXT$;EOL$;
25955        SPC.LOC=INSTR(TEXT$," ")
25960        IF SPC.LOC=1 THEN SPC.LOC=INSTR(2,TEXT$," ")
25965        LN$=LEFT$(TEXT$,SPC.LOC)
25970        LN!=VAL(LN$)
25975        IF LN!>=FIRST AND LN!<=LAST!  THEN ELSE GOTO  26000
25980           PRINT #2,STR$(LN!+1);" ln..!=";LN$;":gosub 60010";EOL$;
25985           MID$(TEXT$,SPC.LOC,1)="*"
```



```
25990         PRINT TEXT$
25995   GOTO   26010
26000   ' ELSE]
26005         PRINT TEXT$
26010       ' IFEnd]
26015     WEND
26020   '
26025   '  Write the debug module on the end of the input file
26030   '
26035     PRINT #2,"60000 end";EOL$;
26040   '
26045     PRINT #2,"60010 if ln..!<begin..! or ln..!>stop..! then";
26046     PRINT" return";EOL$;
26050   '
26055     PRINT #2,"60015 print p..$";CHR$(34);"  [";CHR$(34);
26060     PRINT #2,"ln..!";CHR$(34);"]";CHR$(34);EOL$;
26065   '
26070     PRINT #2,"60020 if pr..% then print #";FLN$",";CHR$(34);
26071     PRINT"  [";CHR$(34);
26075     PRINT #2,"ln..!";CHR$(34);"]";CHR$(34);EOL$;
26080   '
26085     PRINT #2,"60030 if vs..% then gosub 62000";EOL$;
26090   '
26095     PRINT #2,"60040 if ns..% then a..$=inkey$:if a..$<>";
26096     PRINT CHR$(34);" ";CHR$(34);
26100     PRINT #2," then return else ns..%=0";EOL$;
26105   '
26110     PRINT #2,"60050 a..$=input$(1)";EOL$;
26115   '
26120     PRINT #2,"60055 if a..$=";CHR$(34);"D";CHR$(34);
26125     PRINT #2," or a..$=";CHR$(34);"d";CHR$(34);
26130     PRINT #2," then pr..%=-1:p..$=";
26135     PRINT #2,CHR$(34);"D*";CHR$(34);":gosub 63500";EOL$;
26140   '
26145     PRINT #2,"60060 if a..$=";CHR$(34);"P";CHR$(34);
26150     PRINT #2," or a..$=";CHR$(34);"p";CHR$(34);
26155     PRINT #2," then pr..%=-1:p..$=";
26160     PRINT #2,CHR$(34);"P*";CHR$(34);":gosub 63600";EOL$;
26165   '
26170     PRINT #2,"60070 if a..$=";CHR$(34);"N";CHR$(34);
26175     PRINT #2," or a..$=";CHR$(34);"n";CHR$(34);
26180     PRINT #2," then ns..%=-1";EOL$;
26185   '
26190     PRINT #2,"60080 if a..$=";CHR$(34);"V";CHR$(34);
26195     PRINT #2," or a..$=";CHR$(34);"v";CHR$(34);
26200     PRINT #2," then vs..%=-1";EOL$;
26205   '
26210     PRINT #2,"60090 if a..$=";CHR$(34);"R";CHR$(34);
26215     PRINT #2," or a..$=";CHR$(34);"r";CHR$(34);
26220     PRINT #2," then ns..%=0:pr..%=0:vs..%=0:";
26225     PRINT #2,"p..$=";CHR$(34);CHR$(34);EOL$;
26230   '
26235     PRINT #2,"60100 if a..$=";CHR$(34);"C";CHR$(34);
26240     PRINT #2," or a..$="CHR$(34);"c";CHR$(34);
26245     PRINT #2," then gosub 61120";EOL$;
26250   '
26255     PRINT #2,"60105 if a..$=";CHR$(34);"T";CHR$(34);
26260     PRINT #2," or a..$="CHR$(34);"t";CHR$(34);
26265     PRINT #2," then gosub 63010";EOL$;
26270   '
26275     PRINT #2,"60110 return";EOL$;
26280   '
26285     PRINT #2,"61120 vln..!=62010";EOL$;
26290   '
26295     PRINT #2,"61130 open ";CHR$(34);DRV$;":";"variable.mrg";
26296     PRINT CHR$(34);" for ";
26300     PRINT #2,"output as #";FLN2$;EOL$;
26305   '
26310     PRINT #2,"61140 print #";FLN2$;",";CHR$(34);"62000 rem";
26311     PRINT CHR$(34);";eol..$";
26315     PRINT #2,EOL$;
26320   '
26325     PRINT #2,"61150 input";CHR$(34);"Enter variable name: ";
26326     PRINT CHR$(34);",vb..$";
26330     PRINT #2,EOL$;
26335   '
26340     PRINT #2,"61160 if vb..$=";CHR$(34);CHR$(34);
26341     PRINT" then goto 61230";EOL$;
26345   '
26350     PRINT #2,"61170 vln..!=vln..!+10";EOL$;
26355   '
26360     PRINT #2,"61180 print #";FLN2$",str$(vln..!);";CHR$(34);
26361     PRINT " print p..$;";
26365     PRINT #2,CHR$(34);";chr$(34);vb..$;";CHR$(34);"=";CHR$(34);
26370     PRINT #2,";chr$(34);vb..$;eol..$;";EOL$;
26375   '
26380     PRINT #2,"61190 vln..!=vln..!+10";EOL$;
26385   '
26390     PRINT #2,"61200 print #";FLN2$;",str$(vln..!);";CHR$(34);
26391     PRINT" if pr..% then ";
26395     PRINT #2," print #";FLN$;",";CHR$(34);";chr$(34);vb..$;";
26396     PRINT CHR$(34);"=";
26400     PRINT #2,CHR$(34);";chr$(34);vb..$;eol..$;";EOL$;
26405   '
26410     PRINT #2,"61210 vln..!=vln..!+10";EOL$;
26415   '
26420     PRINT #2,"61220 goto 61150";EOL$;
26425   '
26430     PRINT #2,"61230 print #";FLN2$;",";CHR$(34);"63000 return";
26431     PRINT CHR$(34);
26435     PRINT #2,";eol..$;";EOL$;
26440   '
26445     PRINT #2,"61240 close #";FLN2$;EOL$;
26450   '
26455     PRINT #2,"61250 chain merge ";CHR$(34);DRV$;":";
26456     PRINT"variable.mrg";
26460     PRINT #2,CHR$(34);",ln..!+1,all,delete 62000-63000";EOL$;
26465   '
26470     PRINT #2,"61260 return";EOL$;
26475   '
26480     PRINT #2,"62000 rem";EOL$;
26485     PRINT #2,"63000 return";EOL$;
26490   '
26495     PRINT #2,"63010 input";CHR$(34);"Please enter the line";
26496     PRINT" number where ";
26500     PRINT #2," the trace ";
26505     PRINT #2,"will begin: ";CHR$(34);",an..$:if (val(an..$)<10";
26506     PRINT" or val(an..$)";
26510     PRINT #2,">59999) and an..$<>";CHR$(34);CHR$(34);
26515     PRINT #2," then print";CHR$(34);"Invalid entry!";CHR$(34);
26520     PRINT #2,":goto 63010 else if an..$=";CHR$(34);CHR$(34);
26521     PRINT" then begin..!=";
26525     PRINT #2,"first..! else begin..!=val(an..$)";EOL$;
26530   '
26535     PRINT #2,"63020 input";CHR$(34);"Please enter the line";
26536     PRINT" number where ";
26540     PRINT #2 " the trace ";
26545     PRINT #2,"will stop: ";CHR$(34);",an..$:if (val(an..$)<10";
26546     PRINT" or val(an..$)";
26550     PRINT #2,">59999) and an..$<>";CHR$(34);CHR$(34);
26555     PRINT #2," then print";CHR$(34);"Invalid entry!";CHR$(34);
26560     PRINT #2,":goto 63010 else if an..$=";CHR$(34);CHR$(34);
26561     PRINT" then stop..!=";
26565     PRINT #2," last..! else stop..!=val(an..$)";EOL$;
26570   '
26575     PRINT #2,"63030 if begin..!>stop..! then swap";
26576     PRINT" begin..!,stop..!";EOL$;
26580   '
26585     PRINT #2,"63040 return
26590   '
26595     PRINT #2,"63500 close #";FLN$;EOL$
26600   '
26605     PRINT #2,"63510 open ";CHR$(34);DRV$;":";"trace.dbg";
26606     PRINT CHR$(34);
26610     PRINT #2," for append as #";FLN$;EOL$;
26615   '
26620     PRINT #2,"63520 return";EOL$;
26625   '
26630     PRINT #2,"63600 close #";FLN$;EOL$;
26635   '
26640     PRINT #2,"63610 open ";CHR$(34);"lpt1:";CHR$(34);
26641     PRINT #2," for output as #";FLN$;EOL$;
26650   '
26655     PRINT #2,"63620 return";EOL$;
26660   '
26665   '  Ask if to continue
26670   '
26675     CLOSE
26680     PRINT
26685     PRINT
26690   INPUT"Do you wish to run the trace version of your program";ANS$
26695     ANS$=LEFT$(ANS$,1)
26700     IF ANS$="Y" OR ANS$="y" THEN RUN DRV$+":"+FILENAME$+"."+"dbg"
26705   END
```

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BOB SMITH AND TOM PUCKETT

Time on Your Hands

A Patch to DEBUG.COM

Any programmer who has ever had DEBUG unexpectedly display an instruction out of nowhere and then ignore his every attempt to return from Oz would like an explanation of what may have befallen him, in addition to a remedy.

Every now and then DEBUG may act irrationally, even turning belly up, through no fault of the user's. This can happen because of an idiosyncrasy in the interaction between Single-Step Interrupts (SSIs) and Asynchronous Interrupts (ASIs). The SSI (interrupt 01H) is used by DEBUG to regain control after each instruction is executed. It is controlled by the setting of the trap flag in the 8088 flags register. When DEBUG sets the trap flag on, an SSI is signaled after the next instruction. Because DEBUG has stolen that SSI, it can single-step through the code.

ASIs (interrupts 08H through 0FH) are used by external devices to signal that some event has occurred that needs attention. "Asynchronous" here means the interrupt can be signaled at any time during the execution of the code (for example, pressing a key is an asynchronous interrupt) and is independent of that execution. In contrast, synchronous interrupts are invoked by explicit references in the code to the INT instruction—e.g., invoking a DOS function call via INT 21H. The most frequently arising ASI is the timer interrupt,

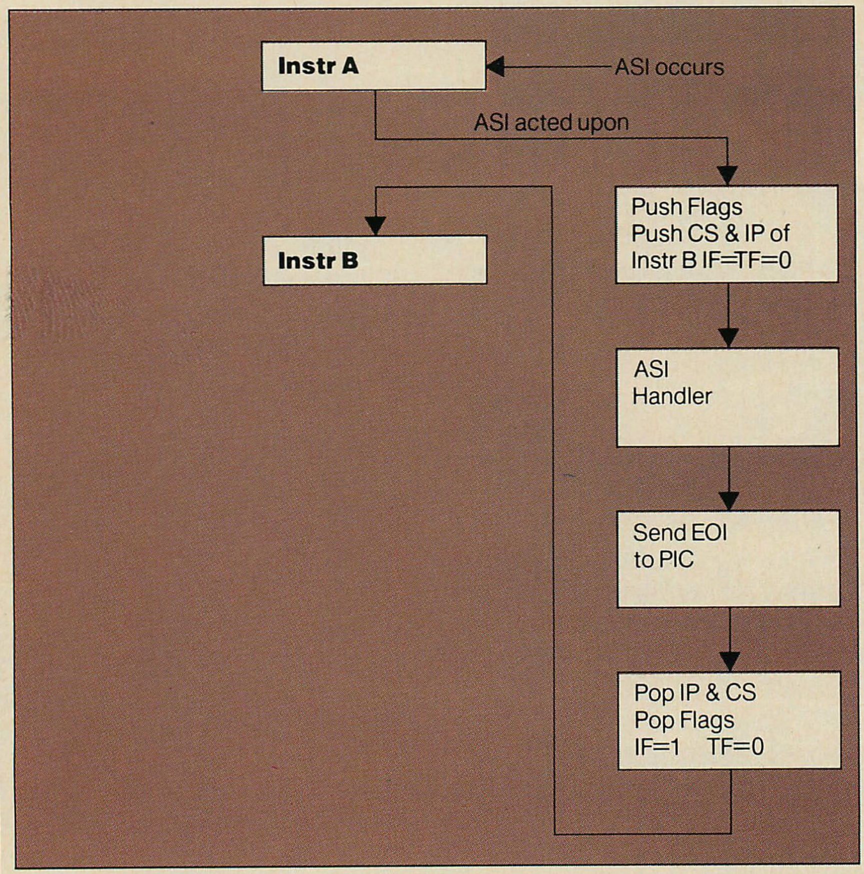

Figure 1:
Outside DEBUG—ASI Occurs. Asynchronous interrupt handling from the 8088's point of view

which is signaled at the rate of about 18.2 times per second. Other such interrupts occur when a key is pressed or released or when a serial communications port, fixed disk, diskette, or parallel printer needs service.

DEBUG's problem appears when an ASI is signaled during the single-step execution of an instruction. To get some idea of the odds of this happening, consider that timer interrupts are signaled once every 54,925 microseconds and the execution time of a single instruction is at most about 40 microseconds and typically about 1 microsecond. However, interrupts are turned off within the single-step routine of DEBUG for about another 75 microseconds, which increases the chances of this problem occurring. Nevertheless, the odds against such an occurrence are about 700 to 1. But when it does happen, the user is dead in the water. This bug has been the subject of much discussion (see references 1, 2, 3, 6, 7, and 8 below) and has burnt users enough times to warrant further investigation.

Throughout the following discussion I assume that interrupts are enabled (by the STI instruction), since if they aren't, ASIs are not acted upon. (In fact, it is exactly ASIs that are controlled by the CLI and STI instructions.)

When an ASI is signaled, it is queued for execution awaiting completion of the current instruction. This task is performed by a system-board chip called the Programmable Interrupt Controller (PIC), an Intel 8259A. The PIC manages all the ASIs and orders them by priority. As set up by BIOS, the highest priority goes to the timer interrupt (used by BIOS to keep the time-of-day current), followed in order by service to the keyboard, serial communications, fixed disk, diskette, and parallel printer. (For a more detailed discussion of the PIC, see "Interrupts and the IBM PC," parts 1 and 2, by Chris Dunford, *PC Tech Journal*, November/December and January issues.)

The priority of different interrupts comes into play when an ASI is signaled while another ASI is being serviced. The PIC queues for later execution ASIs of equal or lower priority than the one currently being serviced. However, if an ASI of higher priority comes along before the previous ASI has finished, the new ASI is acted upon immediately (interrupting the current ASI). Because the PIC is keeping track of interrupts of equal or lower priority that are pending, it needs to be told when they may be passed to the 8088 for servicing. This detail is part of the responsibility of the block of code associated with each ASI (called an interrupt handler). Each ASI handler must send to the PIC an End-Of-Interrupt (EOI) message to clear the current ASI from the PIC's slate.

Figure 1 diagrams the above sequence from the point of view of the 8088. After Instruction A completes execution, the ASI is acted upon. The 8088 processor pushes onto the stack the current flag settings along with

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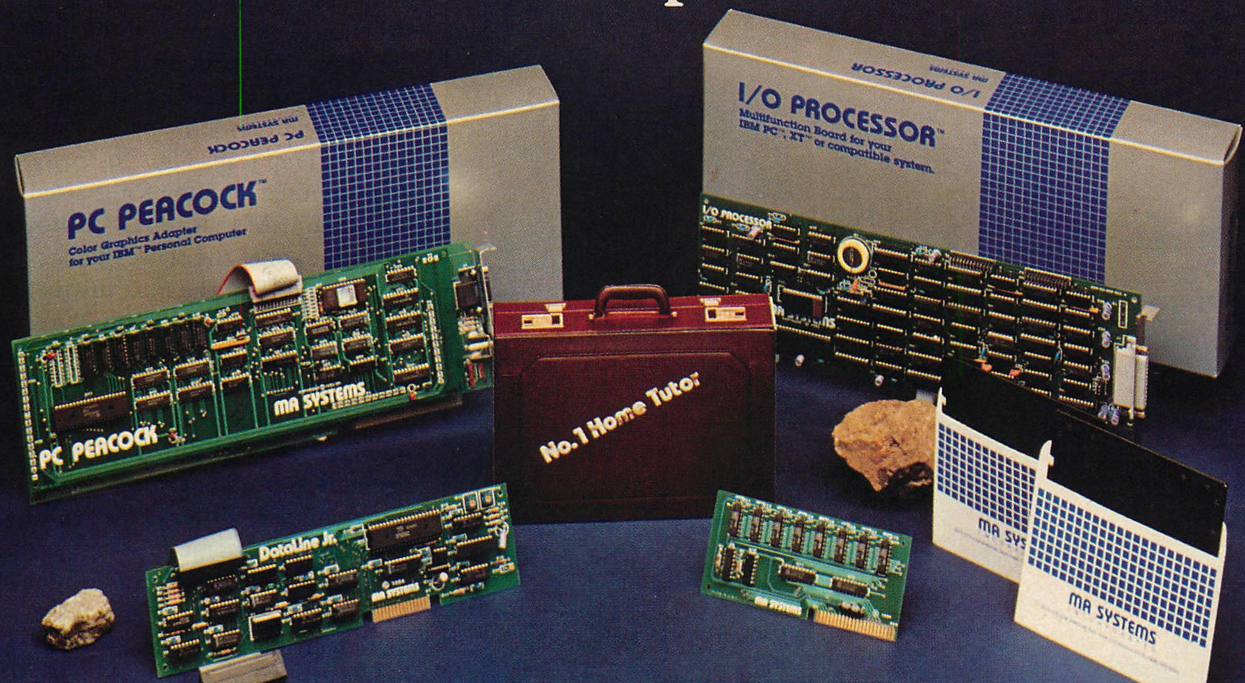

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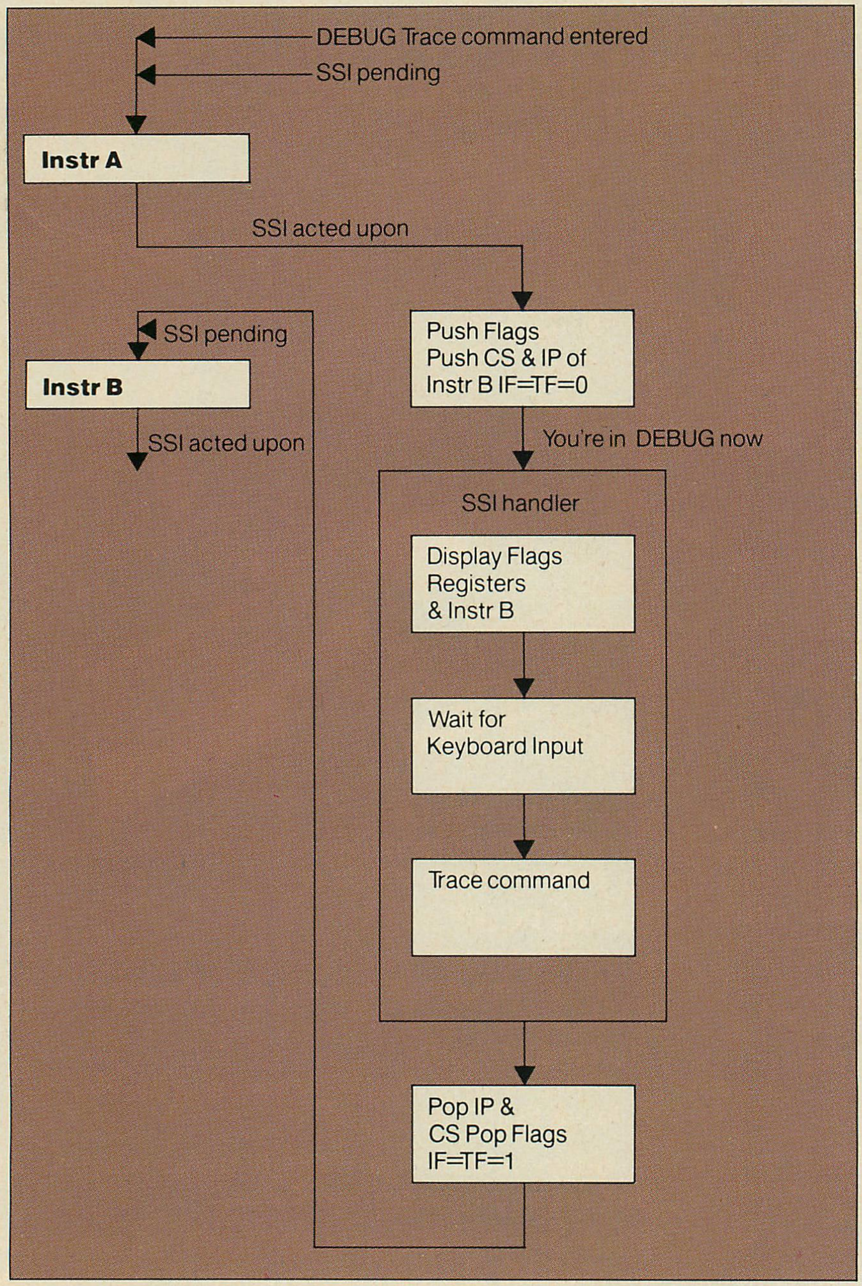

Figure 2: *Old DEBUG—No ASI Occurs. DEBUG's use of the single step interrupt*

the address (segment and offset) of the next instruction (Instruction B). Next, the Interrupt Flag (IF) and Trap Flag (TF) are set to zero (disabled), and the ASI handler is invoked. Sometime during execution, the handler sends an EOI to the PIC. When it completes execution, it restores the flags and resumes execution at the point of interruption.

Figure 2 shows how DEBUG uses the SSI. As mentioned above, the SSI is controlled by the setting of the Trap Flag in the flags register. When DEBUG is asked to single-step through code (via the TRACE command), it turns on the Trap Flag and branches to the next instruction (Instruction A in figure 2) through the use of one instruction (an IRET). The SSI is defined to take effect only after the instruction following the one that sets the Trap Flag. Thus Instruction A is executed, and the SSI is acted upon again. At that time, the processor pushes onto the stack the flags and CS and IP of the next instruction in the program (Instruction B), turns off the Trap and Interrupt Flags, and then invokes the SSI handler.

This handler, which resides inside DEBUG, looks up the stack for the address of the next instruction (Instruction B); displays the registers, flags, and mnemonic for the instruction; and waits for keyboard input. Another TRACE command to DEBUG reenables the Trap Flag and resumes execution with Instruction B. An SSI is recognized once again after that instruction is completed, and the process repeats.

Fine so far, but what happens if while DEBUG is single-stepping through the program, an ASI and an SSI occur "simultaneously"? It might seem hard to believe that, in a system with a 4.77-Mhz processor clock, any two events could take place at the same time. Actually, all that is necessary for simultaneity is for the ASI to materialize during a certain time span. This span includes the execution of an instruction in the program (which may take anywhere from 0.5 to 40 microseconds) and any time immediately preceding the instruction during which interrupts are disabled (in this case, it's about 75 microseconds to restore registers and such, courtesy of DEBUG). Although it's not likely that such a coincidence would occur, it can happen. The question then arises, which interrupt handler is invoked? The unexpected answer is that *both* are.

As diagrammed in figure 3, the ASI handler is invoked first, and then before a single instruction in that

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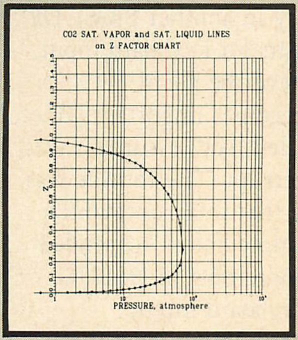

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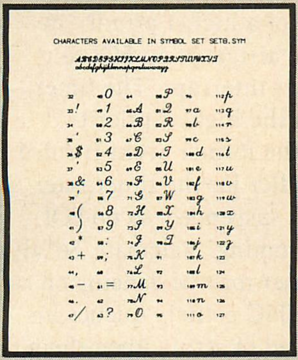

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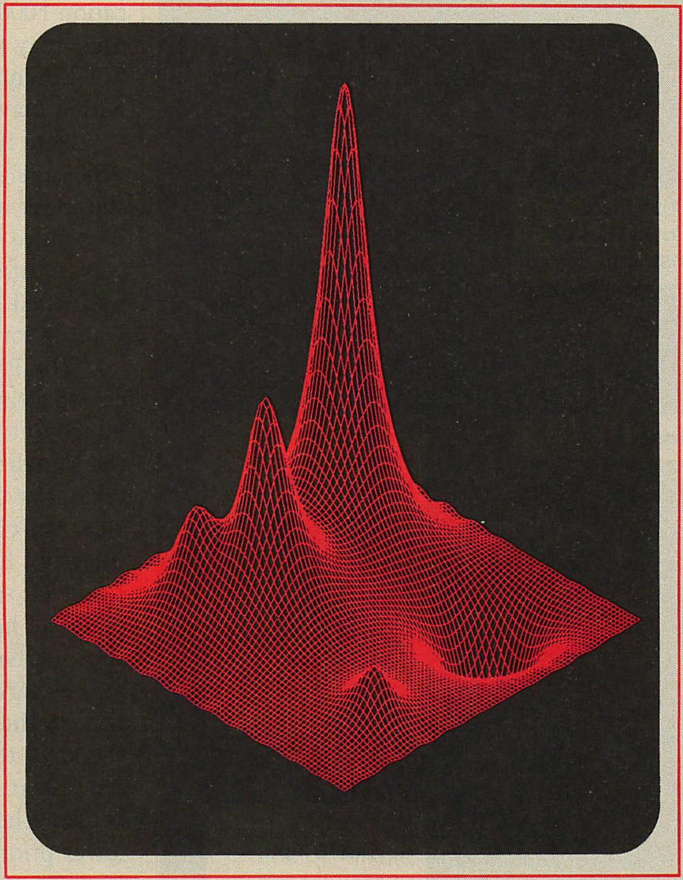

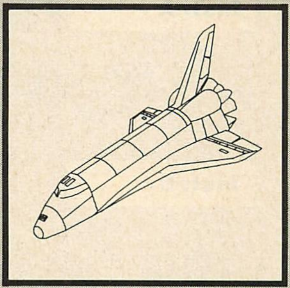

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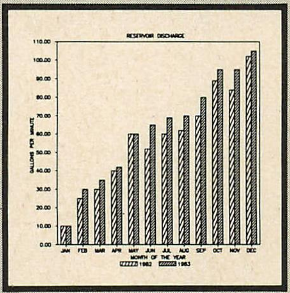

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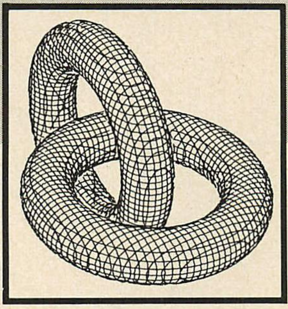
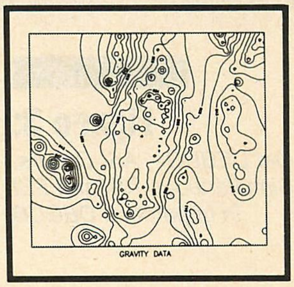


Program Output



Contouring

PLOTCALL is a graphics system that processes standard plotter instructions into a form that can be printed on over 20 dot matrix printers. This is not another print screen program; presentation quality graphics are created directly on the printer to achieve the maximum resolution possible. (120 x 216 dots per inch for Epson printers)

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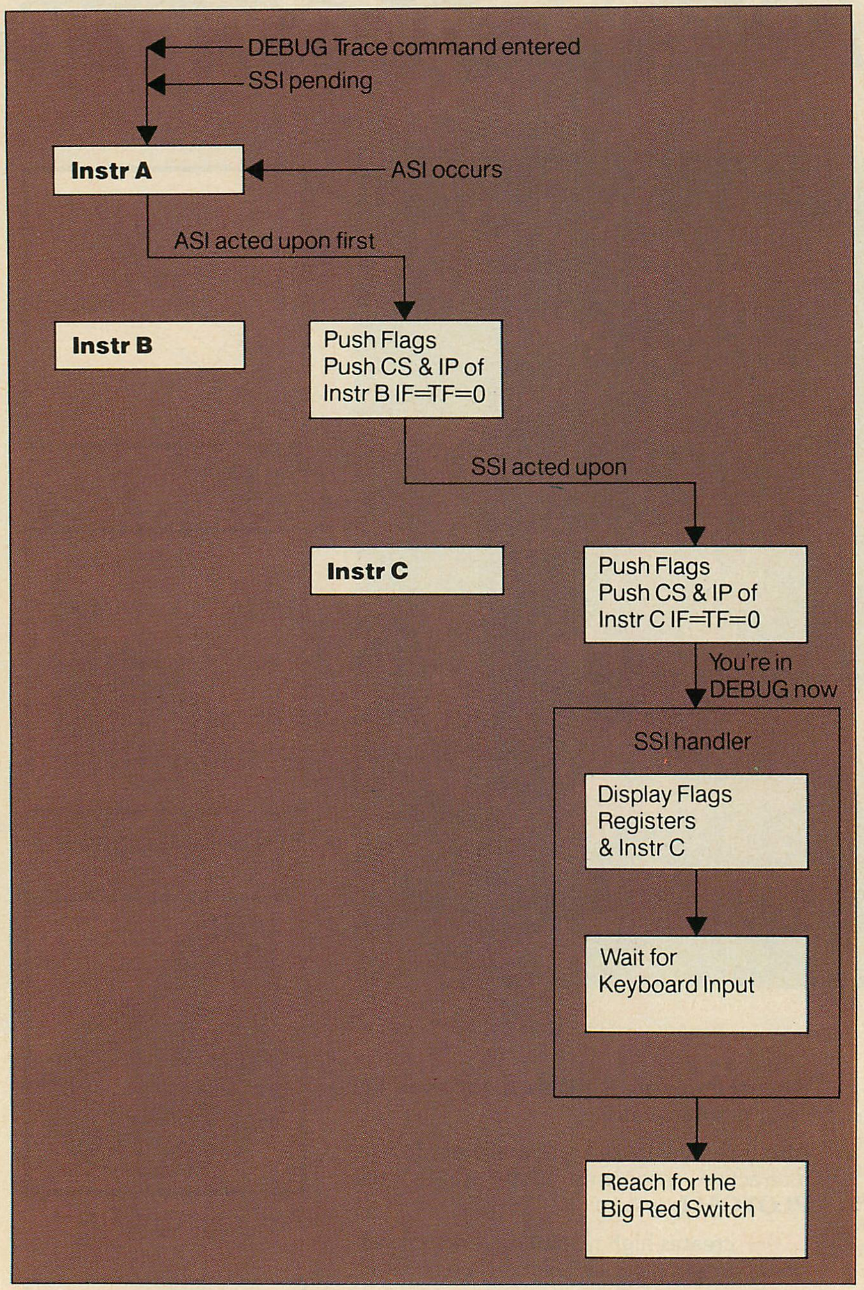

Figure 3:
Old DEBUG—ASI Occurs. Simultaneous ASI and SSI in unpatched DEGUB

handler is executed, the SSI is recognized and its handler invoked. What about the PIC and its orderly queue of interrupts? The SSI is not an ASI, so it is not managed by the PIC.

When this happens, you and Toto know you're not in Kansas anymore because the instruction displayed by DEBUG is not the next one in the routine (which is Instruction B in figure 3). Instead, DEBUG displays the first instruction in the ASI handler (Instruction C); after all, that's the one whose address was pushed onto the stack before the SSI routine was called in DEBUG. For example, if it's the timer interrupt involved, Instruction C is an STI at location F000:FEA5 in BIOS (the address may vary in another BIOS). DEBUG then waits for keyboard input, which may never be heard.

Here it becomes important which ASI was signaled. Let's assume it was the timer interrupt. The routine was suspended by that interrupt, which was in turn immediately suspended by the SSI. We're now in DEBUG waiting for keyboard input.

The PIC remembers that it received a timer interrupt and won't budge until one of two events occurs: the signaling of a higher-priority interrupt or the arrival of an EOI to clear the timer interrupt. The timer interrupt has the highest priority, however, so the former event is ruled out. The handler for the timer interrupt has been suspended, so no EOI will be forthcoming. Stalemate. So, although the user may be dancing on the keys, the PIC politely queues his requests instead of acting upon them, because the keyboard interrupt is of lower priority than the timer interrupt. To return from Oz, the user must power off and then on.

If the suspended ASI is other than the timer interrupt, the situation is the same as described above, except that the PIC won't politely tell the keyboard interrupt to wait in line, because that ASI is higher in priority than the one that is suspended. However, although the keyboard entry makes it through to DEBUG, the right move to make next might not be clear; execution was unexpectedly suspended before the first instruction of the ASI handler—not before the next one in the program. Should the user type Go while setting a breakpoint back in the program or should he gamely single-step his way through an ASI handler?

Fortunately, there's a way out of this predicament. The patch to DEBUG listed below checks to see if the point of interruption is at the first in-

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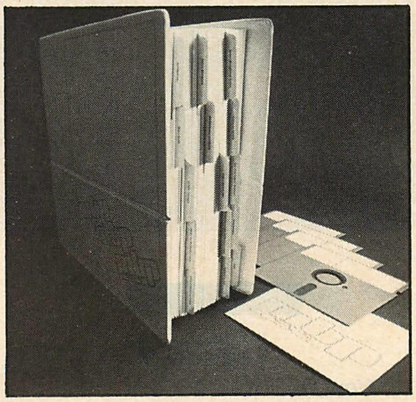

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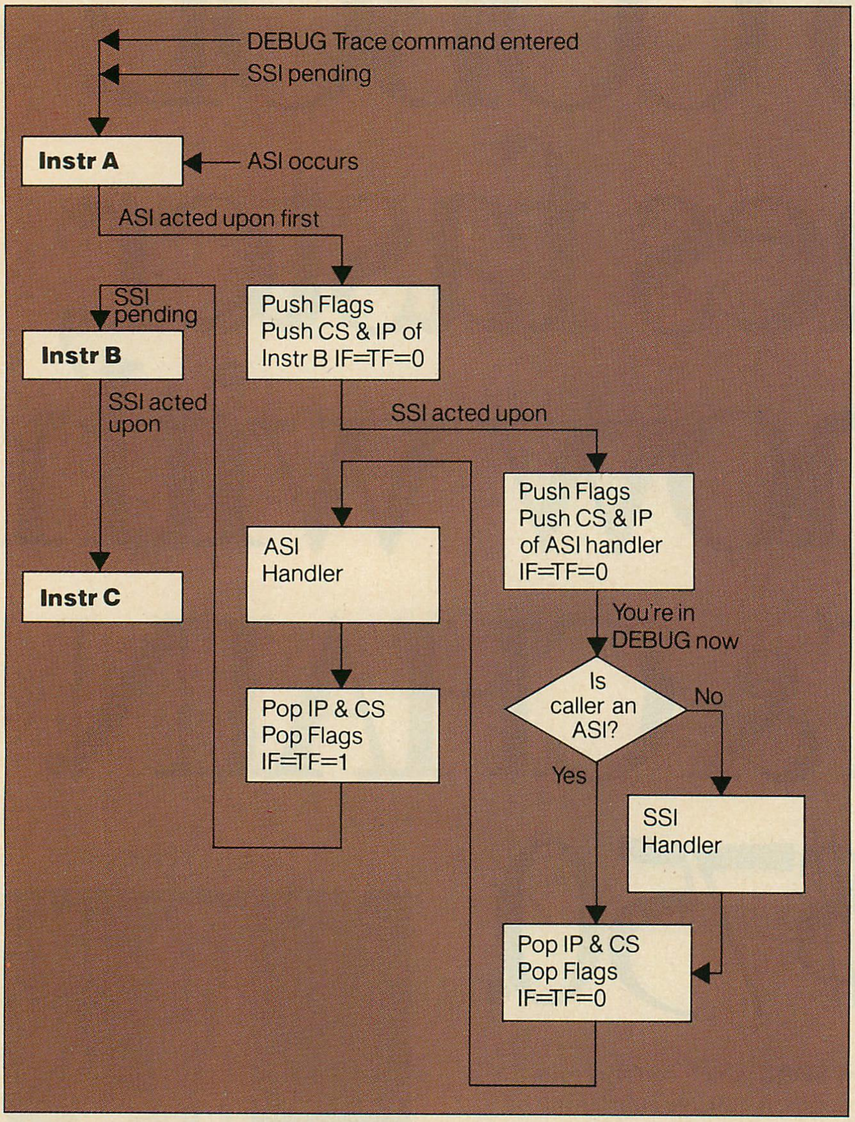

Figure 4:

New DEBUG—ASI Occurs. Simultaneous ASI and SSI after patch to DEBUG

struction in any of the eight potential ASI handlers (08H through 0FH). If so, it resumes execution at the point of interruption in the ASI handler with the Trap Flag off (that is, not in single-step mode). If not, it executes the instructions displaced by the patch and continues normal execution of DEBUG. Note that all ASIs are treated alike even though not all of them need have handlers implemented. The above sequence is diagrammed in figure 4.

The downside risk of this patch is small. Note from figure 4 that in this situation, the new version of DEBUG simply fails to trace Instruction B. To be sure, that instruction is executed; it just isn't traced. First the DEBUG display for Instruction A will appear, then that for Instruction C. This situation is similar to what happens when tracing an instruction that changes a segment register. In that case, too, the instruction that follows is not traced (assuming that the 8088 chip in the machine does not have the bug described in "Tracing a Bug in the 8088," by Will Fastie, *PC Tech Journal*, September/October, 1983). One other downside risk is that it is impossible to trace through an ASI handler that is explicitly called in the code (occurrences of INT 08H through INT 0FH). However, because such handlers are generally invoked only asynchronously, that shouldn't be a problem.

In reference 2, Stephen Baumgartner presents another approach to solving this problem. His patch checks the PIC's in-service register to see if any ASIs are being serviced. If one is, the trace display is skipped and execution continues in the caller (which should be an ASI handler). The downside risk of his patch is also small. Its only flaw is that the patch, by having read the in-service register, may change the state of the PIC. This may present a problem only if the user is tracing code that reads the interrupt request register, another of the PIC's registers. Otherwise, both patches solve the problem.

PATCH TO DOS 1.10 VERSION OF DEBUG

A listing of a session incorporating this patch appears in listing 1. This text consists of the commands to DEBUG to modify a copy of itself. As with any patch, first copy the program to be modified to another diskette. Never modify the original.

It may be desirable to change the two name (n) commands to suit a particular system. The first one (N DEBUG.COM) names the file to be loaded. If the copy to be modified is on a different drive, insert the drive letter, as in N B:DEBUG.COM. The second command (N DBG1FIX.COM) names the modified file. This file can

Personal Telephone Management

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Written by Isaac M. Alderidge

BELLEVUE, WA—A manager plans to use it to track progress of his sales people while he's away on business trips.

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Much of CMC advertising centers around this visual depicting the fusion of telephone, voice and the IBM PC.

Enthusiastic Response

CMC International, a five-year-old public company specializing in peripheral products for the IBM® PC has introduced what it believes to be the first such system for the personal computer. After two years in development and testing the company is set to ship its first pc-DIAL/LOG™ production models. The product received an enthusiastic welcome at its recent unveiling to analysts and the press.

"Almost everyone who has seen the product comments on how they can use pc-DIAL/LOG," says Gerald Jones, CMC International executive vice president. "Acceptance is unbelievable. Computer stores are anxious to get pc-DIAL/LOG on their shelves. Many OEM and system houses have signed orders and are rushing to bundle the product with pc-based hardware. People realize the impact this type of technology brings to the pc market."

CMC's Entry

The CMC device, an expansion-type circuit board with software is designed to run on the IBM® PC or compatible computers. With pc-DIAL/LOG installed the computer is able to perform a number of telephone functions including digitally recording, saving, and sending voice messages. CMC's method allows exact reproduction of the user's voice.

Priced at under $1,000, the product offers capabilities similar to much and more complicated systems which range from $2,500 to $50,000. Although primarily designed for business, its low cost also makes it practical for home use.

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Markets include the medical, legal and accounting professions, stock brokers, sales organizations, and a variety of small companies and Fortune 1000 departments, according to market studies.

Applications include message distribution, appointment reminders, telephone marketing, polling, and research.

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Take a task as mundane as that of notifying club members of an upcoming meeting as an example of pc-DIAL/LOG's electronic wizardry.

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CMC's pc-DIAL/LOG requires an IBM® PC or equivalent with 192K bytes of RAM and dual floppy disks. A telephone is used for recording. The package comes complete with hardware, software, manual, necessary phone cables and a telephone key-pad guide for remote access of functions.

Hard disk subsystems like CMC's TARGA™ or hard disk-equipped computers like the IBM® XT can further enhance the peripheral by providing more space for storing voice messages.

CMC's device is designed for simple plug-in installation. Software is easy to understand. Operation is menu driven which means all functions are displayed on the screen at the same time.

At a glance, a pc-DIAL/LOG owner sees who has called, at what time, what messages were sent and received, how much recording time remains and so forth.

Continuing R & D

Company officials indicate the pc-DIAL/LOG marks CMC's further diversification into advanced pc technology. The company will announce more peripherals in coming months but declined to be more specific.

Meanwhile, CMC believes they have a winner and the enthusiasm of another electronics company executive seems to validate their belief.

"It's neat! pc-DIAL/LOG frees me from the telephone when I have more important things at hand. It makes me more productive."

For information on pc-DIAL/LOG contact CMC International at 1-800-262-4685. (1-206-885-1600 in Washington.) Reprints of this article are available from CMC. ■

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take on any name but must remain a .COM file. If the input and output files are to be the same, the second name command may be omitted.

Except for the segment numbers (displayed as xxxx) and the comments preceded by a semicolon, the output should identically match that of listing 1. To further ensure correctness, try setting Ctrl-PrtSc on to send each line to the printer as it is entered; the output can then be checked against listing 1 before the changed routine is written to disk. If it matches the listing, rename the new file DEBUG.COM.

PATCH TO DOS 2.00 VERSION OF DEBUG

DOS 2.00 allows redirection of I/O, which can simplify this task. Create a file (say DBG2FIX.IN) that contains the text listed in listing 2. The text consists of the commands to DEBUG to modify a copy of itself. Never modify the original copy.

The two name commands may be changed as in the discussion above. Note that listing 2 indicates two places to insert a blank line in the file; these blank lines tell DEBUG there are no more instructions for the assemble command.

To invoke the input file, use

DEBUG<DBG2FIX.IN

Listing 3 contains the output of such a session. To capture the output to compare against listing 3, use

DEBUG<DBG2FIX.IN > DBG2FIX.OUT

Note that it's important to enter a space before the right caret, which redirects the output. Again, except for the segment numbers (displayed as xxxx) and the comments preceded by a semicolon, the output should identically match that of listing 3. If everything tallies, rename the new file DEBUG.COM.

With these techniques, DEBUG will behave rationally even when ASIs and SSIs overlap, allowing programmers to spend more time programming and less time trying to figure out how to return from Oz.

Bob Smith is president of Qualitas, Inc., an IBM PC software vendor located in Bethesda, Maryland. Tom Puckett is a senior systems programmer for STSC, Inc. in southern New Mexico. His primary responsibility is support software for STSC's products for the IBM PC and similar machines.

Listing 1 DOS 1.10 DEBUG Patch Session

```
A>DEBUG
-N DEBUG.COM              ; MODIFY IF INPUT ON ANOTHER DISK
-L                        ; LOAD THE NAMED FILE
-N DBG1FIX.COM            ; MODIFY IF OUTPUT ON ANOTHER
                          ; DISK OR YOU WISH TO USE ANOTHER NAME
-U 852 L 4                ; ENSURE YOU HAVE THE CORRECT LOCATION
XXXX:0852 33C0        XOR     AX,AX
XXXX:0854 8ED8        MOV     DS,AX
-E 852                    ; ENTER THE CALL TO THE PATCH AREA
XXXX:0852  33.E8   C0.5D   8E.12   D8.90
-U 852 L 4                ; ENSURE CODE ENTERED CORRECTLY
XXXX:0852 E85D12      CALL    1AB2
XXXX:0855 90          NOP
-E 1AAE 20 00 00 00       ; ENTER THE DATA
-D 1AAE L 4               ; ENSURE DATA ENTERED CORRECTLY
XXXX:1AAE  20 00
XXXX:1AB0  00 00                                         ..
-E 1AB2 53 51 57 06 C4 3E AE 1A A1 62 18 8B 1E 60 18 B9 08 00
-E 1AC4 26 3B 05 75 09 26 3B 5D 02 75 03 E9 08 ED 83 C7 04
-E 1AD5 E2 ED 07 5F 59 5B 33 C0 8E D8 C3
-U 1AB2 L 2E              ; ENSURE CODE ENTERED CORRECTLY
XXXX:1AB2 53          PUSH    BX
XXXX:1AB3 51          PUSH    CX
XXXX:1AB4 57          PUSH    DI
XXXX:1AB5 06          PUSH    ES
XXXX:1AB6 C43EAE1A    LES     DI,[1AAE]
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```
XXXX:1ABA A16218      MOV    AX,[1862]
XXXX:1ABD 8B1E6018    MOV    BX,[1860]
XXXX:1AC1 B90800      MOV    CX,0008
XXXX:1AC4 26          SEG    ES
XXXX:1AC5 3B05        CMP    AX,[DI]
XXXX:1AC7 7509        JNZ    1AD2
XXXX:1AC9 26          SEG    ES
XXXX:1ACA 3B5D02      CMP    BX,[DI+02]
XXXX:1ACD 7503        JNZ    1AD2
XXXX:1ACF E908ED      JMP    07DA
XXXX:1AD2 83C704      ADD    DI,+04
XXXX:1AD5 E2ED        LOOP   1AC4
XXXX:1AD7 07          POP    ES
XXXX:1AD8 5F          POP  - DI
XXXX:1AD9 59          POP    CX
XXXX:1ADA 5B          POP    BX
XXXX:1ADB 33C0        XOR    AX,AX
XXXX:1ADD 8ED8        MOV    DS,AX
XXXX:1ADF C3          RET
-R CX                    ; IF EVERYTHING ABOVE MATCHES
CX 176F                  ;  TELL DEBUG HOW MUCH DATA TO
:1AE0                    ;  WRITE OUT
-W                       ; WRITE TO DISK
WRITING 1AE0 BYTES
-Q                       ; EXIT TO DOS TO TRY THE PATCH
A>
```

Listing 2 DOS 2.00 DEBUG Patch Input

```
N DEBUG.COM
L
N DBG2FIX.COM
U 934 L 4
A 934
CALL 2E84
NOP
                          ; BE SURE THERE'S A BLANK LINE HERE
U 934 L 4
A 2E80
DW 20,0
PUSH BX
PUSH CX
PUSH DI
PUSH ES
LES DI,[2E80]
MOV AX,[2AFA]
MOV BX,[2AF8]
MOV CX,8
ES:
CMP AX,[DI]
JNE 2EA4
ES:
CMP BX,[DI+2]
JNE 2EA4
JMP 8B6
ADD DI,4
LOOP 2E96
POP ES
POP DI
POP CX
POP BX
XOR AX,AX
MOV DS,AX
RET
                          ; ANOTHER BLANK LINE GOES HERE
D 2E80 L 4
U 2E84 L 2E
R CX
2EB2
W
Q
```

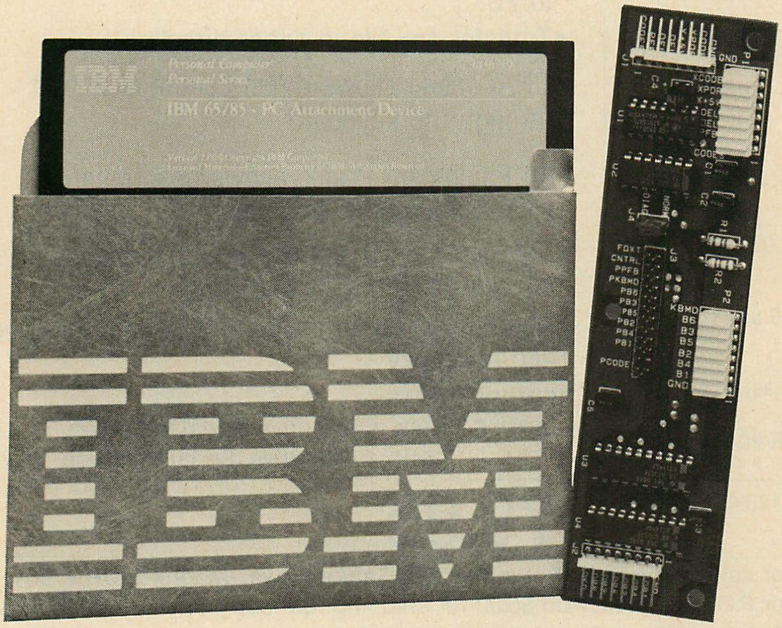
Listing 3 DOS 2.00 DEBUG Patch Output

```
A>DEBUG<DBG2FIX.IN
-N DEBUG.COM                  ; MODIFY IF INPUT ON ANOTHER DISK
-L                            ; LOAD THE NAMED PROGRAM
-N DBG2FIX.COM                ; MODIFY IF OUTPUT ON ANOTHER DISK
                              ;  OR YOU WISH TO USE ANOTHER NAME
-U 934 L 4                    ; ENSURE YOU HAVE THE CORRECT LOCATION
XXXX:0934 33C0      XOR    AX,AX
XXXX:0936 8ED8      MOV    DS,AX
-A 934                        ; ASSEMBLE THE CALL TO THE PATCH AREA
XXXX:0934 CALL 2E84
XXXX:0937 NOP                 ; NOP USED AS YOU'RE REPLACING 4 BYTES
XXXX:0938
-U 934 L                      ; ENSURE CODE ENTERED CORRECTLY
XXXX:0934 E84D25    CALL   2E84
XXXX:0937 90        NOP
-A 2E80                       ; AT THE PATCH AREA, ASSEMBLE
XXXX:2E80 DW 20,0             ;  IN THE DATA AND INSTRUCTIONS
XXXX:2E84 PUSH BX
XXXX:2E85 PUSH CX
XXXX:2E86 PUSH DI
XXXX:2E87 PUSH ES
XXXX:2E88 LES DI,[2E80]
XXXX:2E8C MOV AX,[2AFA]
XXXX:2E8F MOV BX,[2AF8]
XXXX:2E93 MOV CX,8
XXXX:2E96 ES:
XXXX:2E97 CMP AX,[DI]
XXXX:2E99 JNE 2EA4
XXXX:2E9B ES:
XXXX:2E9C CMP BX,[DI+2]
XXXX:2E9F JNE 2EA4
XXXX:2EA1 JMP 8B6
XXXX:2EA4 ADD DI,4
XXXX:2EA7 LOOP 2E96
XXXX:2EA9 POP ES
XXXX:2EAA POP DI
XXXX:2EAB POP CX
XXXX:2EAC POP BX
XXXX:2EAD XOR AX,AX
XXXX:2EAF MOV DS,AX
XXXX:2EB1 RET
XXXX:2EB2
-D 2E80 L 4                         ; ENSURE DATA ENTERED CORRECTLY
XXXX:2E80  20 00 00 00                                            ...
-U 2E84 L 2E                        ; ENSURE CODE ENTERED CORRECTLY
XXXX:2E84 53             PUSH   BX
XXXX:2E85 51             PUSH   CX
XXXX:2E86 57             PUSH   DI
XXXX:2E87 06             PUSH   ES
XXXX:2E88 C43E802E       LES    DI,[2E80]
XXXX:2E8C A1FA2A         MOV    AX,[2AFA]
XXXX:2E8F 8B1EF82A       MOV    BX,[2AF8]
XXXX:2E93 B90800         MOV    CX,0008
XXXX:2E96 26             ES:
XXXX:2E97 3B05           CMP    AX,[DI]
XXXX:2E99 7509           JNZ    2EA4
XXXX:2E9B 26             ES:
XXXX:2E9C 3B5D02         CMP    BX,[DI+02]
XXXX:2E9F 7503           JNZ    2EA4
XXXX:2EA1 E912DA         JMP    08B6
XXXX:2EA4 83C704         ADD    DI,+04
XXXX:2EA7 E2ED           LOOP   2E96
XXXX:2EA9 07             POP    ES
XXXX:2EAA 5F             POP    DI
XXXX:2EAB 59             POP    CX
XXXX:2EAC 5B             POP    BX
XXXX:2EAD 31C0           XOR    AX,AX
XXXX:2EAF 8ED8           MOV    DS,AX
XXXX:2EB1 C3             RET
-R CX                               ; IF EVERYTHING ABOVE MATCHES,
CX 2E80                             ;  TELL DEBUG HOW MUCH DATA TO
:2EB2                               ;  WRITE OUT
-W                                  ; WRITE TO DISK
WRITING 2EB2 BYTES
-Q                                  ; EXIT TO DOS TO TRY THE PATCH
A>
```

ARTHUR A. GLECKLER

IBM'S New Alternative To Letter-Quality Printing

Owners of IBM 65 or 85 Electronic Typewriters can now connect them to their PCs with IBM's new Attachment Device



When IBM introduced the PC, the only printer that it sold was the IBM Personal Computer Printer, a dot matrix printer that bore a striking resemblance to the Epson MX-80 printer. Soon after, IBM added the IBM Graphics Printer to its product line for the PC. This printer, which also uses dot matrix technology, is a slightly enhanced version of the earlier printer. Although IBM has yet to introduce a letter-quality printer, it now offers an interesting alternative: an interface (or, as IBM calls it, an Attachment Device) for connecting IBM's Electronic 65 and 85 typewriters to the PC.

The Attachment Device is a small printed circuit board, installed inside the Electronic 65 or Electronic 85 typewriter, which permits the typewriter to be connected to a standard parallel printer interface in the PC. After a simple driver program is installed on the PC, the typewriter behaves like an ordinary line printer, except that it outputs letter-quality print. In addition, the typewriter can still be used as a typewriter without disconnecting it from the computer.

For people who already own an IBM electronic typewriter, the Attachment Device is a bargain at $225. It is rare that any printer—much less one that prints letter-quality type—can be found at such a price. IBM is apparently trying to capture the interest of businesses that have recently converted to word processing on the PC but that still own an IBM electronic typewriter.

INSTALLATION

Since the typewriter must be opened to install the Attachment Device, IBM has chosen to have its own customer representatives install the device on site. The price of the interface includes installation, and IBM does *not* require that the typewriter be taken to one of its service centers.

The Attachment Device itself is

Arthur A. Gleckler is a senior at the Gilman School in Baltimore.

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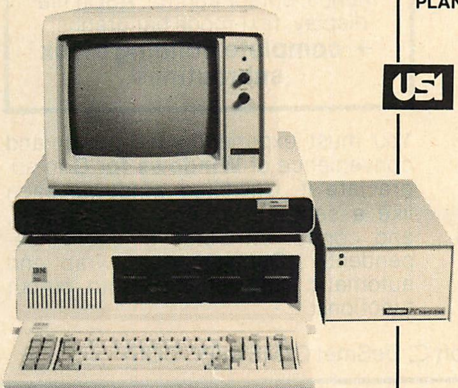

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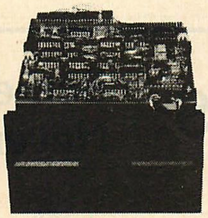

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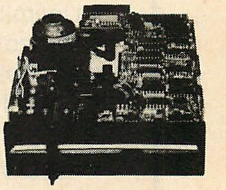

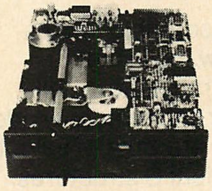

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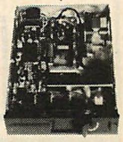

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a small printed circuit board (about 4 by 10 centimeters) with only a handful of chips. It has two connectors on it, one at the typewriter end and one at the computer end.

OPERATION

Included with the Attachment Device are two programs, DIAGSTW and STARTTW. DIAGSTW is the DIAGnosticS program for the TypeWriter and should be run after installation and whenever problems occur. It will report a probable location for any problem when it finishes. STARTTW must be installed to use the typewriter, because the Attachment Device does not use the parallel printer port as a standard printer does.

STARTTW is invoked from DOS in the following format:

STARTTW printer_selection / page_length / type_element

The printer_selection parameter is the number (1, 2, or 3) of the parallel port to which the typewriter is attached. The page_length parameter is the number of lines (between 0 and 255) that the typewriter should print on each page. If a page_length of zero is used, the program assumes that the typewriter will be using continuous-form paper. The third parameter, the type_element, specifies which of two types of type balls the typewriter is using. It may be either an *A*, for ASCII elements, or a *C*, for correspondence elements (i.e., Courier, Prestige, Elite, Title).

Because both the Electronic 65 and the Electronic 85 are primarily designed for manual single-sheet feeding and because no automatic single-sheet feeder is available for either typewriter, the STARTTW program must provide a means to stop printing at the end of each page to allow a new sheet of paper to be inserted. At the end of every *n* lines, where *n* is the page_length parameter specified in the STARTTW program, the PC emits a pleasant chime and waits for the paper in the typewriter to be changed. The user presses the space bar to stop the chime, replaces the paper in the typewriter with a new sheet, and presses <CTRL> <ENTER> to continue printing.

Tabs and margins can be set from the typewriter's keyboard; any settings made from there will be used when printing. To prepare the typewriter for information from the PC, the user must press the Code and ARtn keys simultaneously until the typewriter's indicator lights are extinguished. This setup procedure only needs to be done when the typewriter is first turned on.

The print quality of the Electronic 65 and 85 typewriters is excellent, far better than many more expensive letter-quality printers. Because IBM manufactures a wide variety of ball-type elements, there are many type styles to choose from.

Tech Specs

Using *PC Magazine*'s printer speed test program (see PC Magazine, October, 1983), I clocked the IBM Electronic 85 typewriter at about 13 characters per second, or 12 lines per minute. This compares favorably to many low-cost, letter-quality printers available on the PC market today. However, when the additional time involved in changing sheets of paper (approximately 15 seconds per page) is taken into account, these figures are less impressive.

The Electronic 65 and 85 typewriters recognize a limited set of control codes. Codes for form feed, carriage return, underlining, setting the page length, and other functions are provided (see table 1).

Character Code	ASCII Symbol	Description of Function
0	NUL	Has no effect
9	HT	Moves the typewriter print mechanism to the next tab position; tab positions can be set from the typewriter or with an ESC-D control-character sequence
11	VT	Vertical tabs are not implemented; rather, a single linefeed is substituted
12	FF	Form feed; the typewriter stops printing and the computer chimes, just as if the last line of the page had been reached
27 45 n	ESC-n	Turns underline mode on if n is 1, turns underline mode off if n is 0
27 67 n	ESC C n	Sets the page length to n lines
27 68 n . . .	ESC D n . . .	Sets up to 32 tab positions
27 105	ESC i	Turns continuous underline mode off if it is on, otherwise underlines the preceding word
27 117	ESC u	Starts continuous underline mode

Table 1: Control Codes for IBM's Electronic 65 and 85 Typewriters

Conclusion

The IBM Electronic 65/85 Typewriter Attachment Device offers a competitive alternative to letter-quality printers for people who already own those typewriters. Its combination of low cost and high print quality is attractive. On the other hand, the lack of an automatic single-sheet feeder or even a tractor-feed mechanism makes the typewriter less than convenient when used as a printer.

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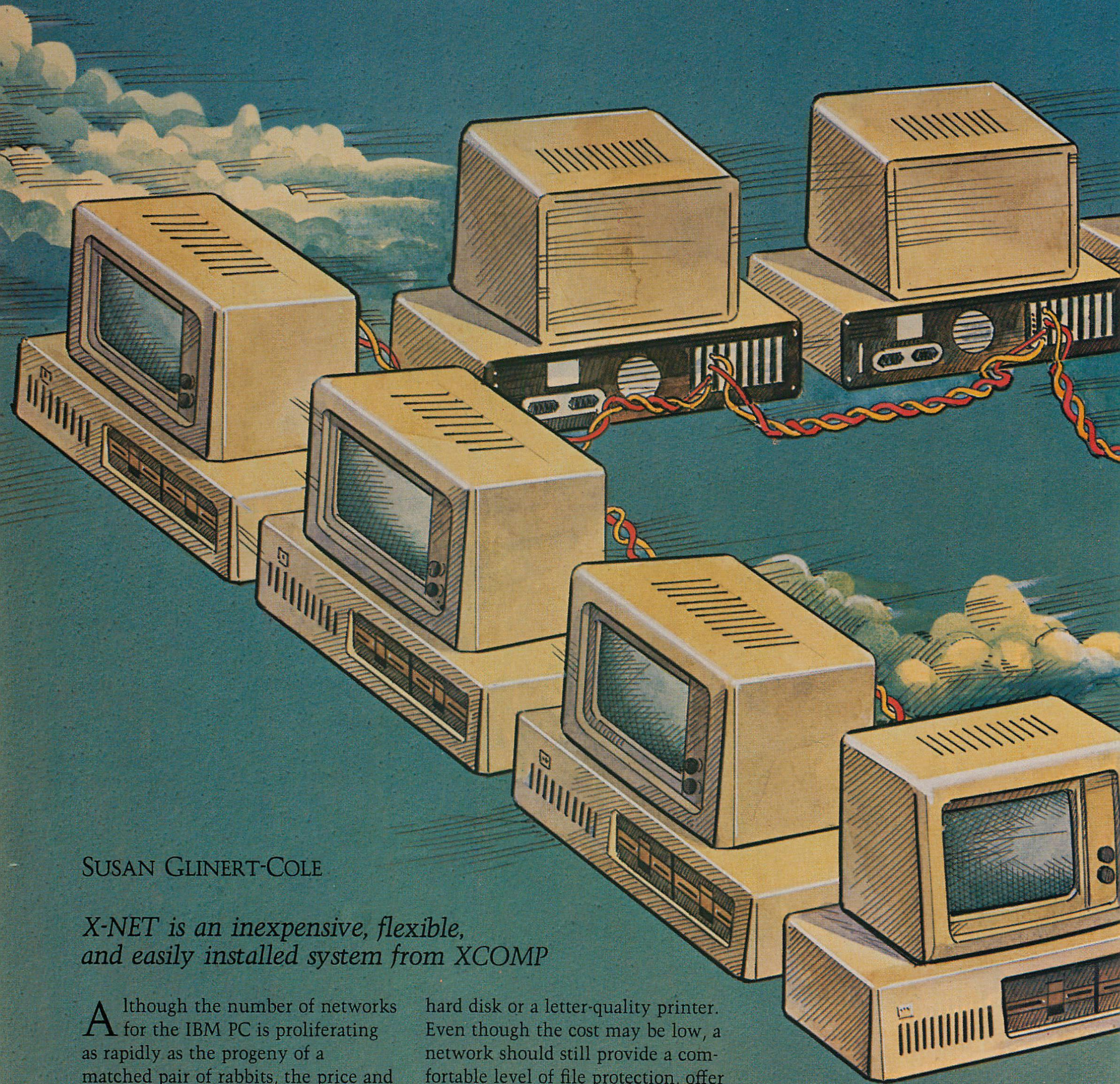


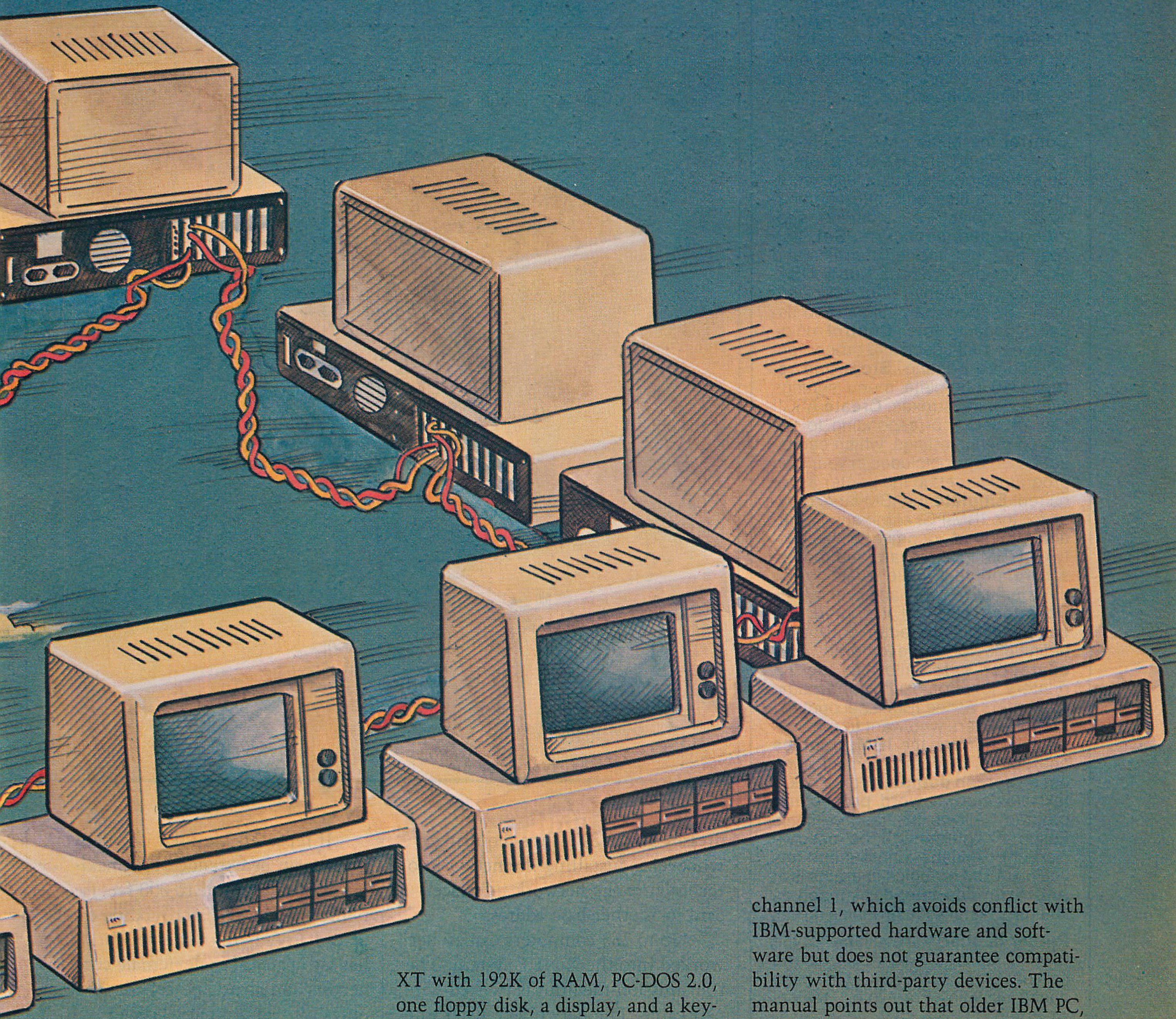
Susan Glinert-Cole

X-NET is an inexpensive, flexible, and easily installed system from XCOMP

Although the number of networks for the IBM PC is proliferating as rapidly as the progeny of a matched pair of rabbits, the price and performance (of the networks, not the rabbits) varies widely. Inexpensive networks are useful for situations in which only a few computers are to be laced together, perhaps to share a hard disk or a letter-quality printer. Even though the cost may be low, a network should still provide a comfortable level of file protection, offer reasonable performance, and be easy to install and use.

X-NET, a low-cost network from XCOMP, features file server emulation without the additional investment of a dedicated file server. Instead of the usual high-priced coaxial cable, inexpensive twisted pair wire links the network together—another cost-saving feature. The network soft-

on Networking



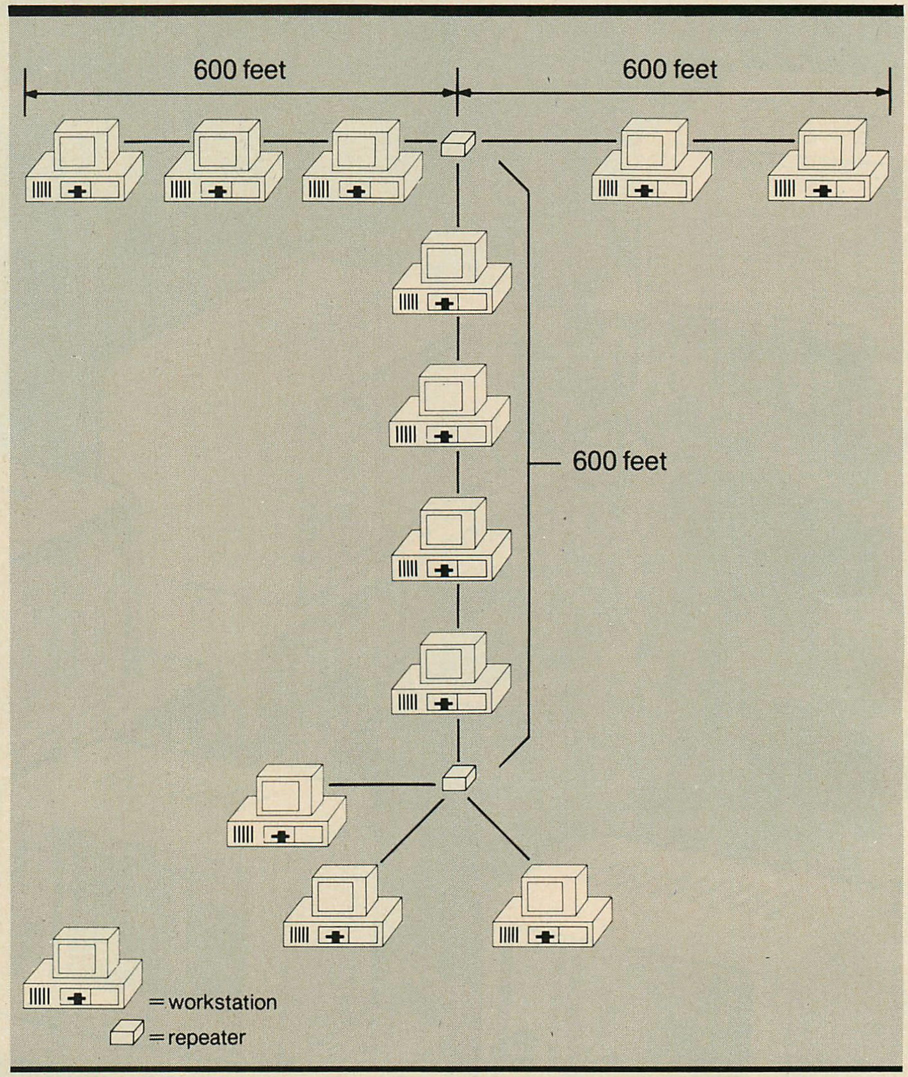
ware is well designed; to set it up requires no special knowledge on the part of the customer. As is the case with most networks that do not use a separate file server, a performance penalty is extracted.

The minimum system requirements for X-NET are an IBM PC or XT with 192K of RAM, PC-DOS 2.0, one floppy disk, a display, and a keyboard. XCOMP recommends 256K of memory and two disk drives for maximum performance. A hard disk, however, is not required.

X-NET uses carrier sense multiple access with collision detect (CSMA/CD). The network interface card uses interrupt level 2 and DMA channel 1, which avoids conflict with IBM-supported hardware and software but does not guarantee compatibility with third-party devices. The manual points out that older IBM PC, Sigma, and Quadram memory expansion boards do conflict with X-NET's usage of DMA channel 1. All three companies have acknowledged the problem and, according to XCOMP, will repair or replace the boards. The Quadram board has an additional conflict: its clock uses the device ad-

ILLUSTRATION • JOE SCROFANI

Figure 1 *X-NET Topology*



dresses 310 to 317, thus requiring whoever is installing the network to reconfigure the network interface card to another base address.

Up to 255 computers can be networked into the X-NET system. The transmission medium is twisted wire pair cable. The network transfer rate is 2.5 megabits per second for bus lengths up to 600 feet. The network is nominally a straight-line bus, with a maximum length of 600 feet. However, 4-port signal repeaters can be used to extend the length of a single network or to join single networks together in an X- or T-shaped bus.

If repeaters are used, the network length can be extended to a maximum bus length of 10,000 feet (see figure 1). The repeater module can be placed anywhere in the network. It has two pairs of male/female connectors and an AC power adapter that plugs into an ordinary 110-volt wall outlet. A repeater is installed between two nodes in one single-bus network or between the two end nodes of two single-bus networks. All four of the connectors can be attached to different nodes. Unused repeater connectors must be terminated with provided terminators.

SYSTEM SET-UP

The X-NET starter kit, priced at $995, contains two adapter boards, two terminator plugs, 50 feet of twisted pair cable with "D" connectors at each end, one diskette containing the X-NET software, and installation and user's manuals. A single-node expansion kit—containing an adapter board, 25 feet of wire, and a user manual—is also available for $495. Should the network require repeaters, a repeater kit can be purchased for an additional $395. This kit contains a repeater module, an AC power adapter plus cord, ten feet of cable, and two terminator plugs.

The documentation is amusingly written, informative, and contains some interesting admonishments. The tone keeps the reader interested; it is, after all, difficult to make technical information palatable enough that a reader will be sure to read the manual thoroughly. The manual specifies that a person with "strong moral fiber" should be delegated as the network administrator. Should your organization lack such an individual, a person with a strong grasp of the technical aspects of the IBM PC would probably serve the purpose. A data administrator should also be selected. This individual "should find exhiliration in occasionally working at odd hours of the day and night, and weekends." Sound advice is proffered regarding backups, file maintenance and archiving.

Installation involves setting two sets of DIP switches on the adapter cards, placing a card into each computer in the network, attaching the cables, and making a network boot diskette for each node. Each node on the network must be assigned a unique address in the range of 0 to 254. Address 255 is reserved by the network for broadcast messages.

Physical assignment is done by setting up an eight-position DIP switch on the adapter card to reflect the binary representation of the address. Another DIP switch on the network card is used to set the eight de-

vice addresses used by X-NET. The switch is preset at the factory with device addresses of 310-317. If these addresses conflict with other devices in the PC, the DIP switch must be reset to another base address. It is not necessary for all nodes in the network to have the same base address or to use the same DMA channel. Once these switches are set, the board is installed into any slot in the PC, PC/XT, or expansion chassis.

The rear of the network card has one male and one female "D" connector. Each segment of the twisted pair cable also has a male and female connector. Cabling is virtually idiot-proof; a connector is simply plugged into any complementary connector. All unused connectors must be terminated with one of the provided terminators. The set-up is designed for easy removal of a node: just unplug the male and female connectors from the network card and then plug the free cable ends to each other.

Once the hardware is installed, it can be checked out using the XNTEST.COM program. This utility is run at a single node under PC-DOS and will check the network interface card, terminator, and cable for integrity. Although XNTEST does not generate specific error messages, the defective hardware can be pinpointed by running XNTEST first with the network interface card, then with the card plus the terminators, and then with the card with terminators and wire installed. The manual is not clear about the specific hardware configurations required to extract meaningful information from XNTEST, but XCOMP encourages users to contact the company if they encounter any problems. When we did so, we were helped promptly, efficiently, and courteously.

Software Installation

The network management program PAXNET is implemented as a device driver, becoming part of DOS 2.0 when installed. X-NET intercepts all DOS system requests, determines

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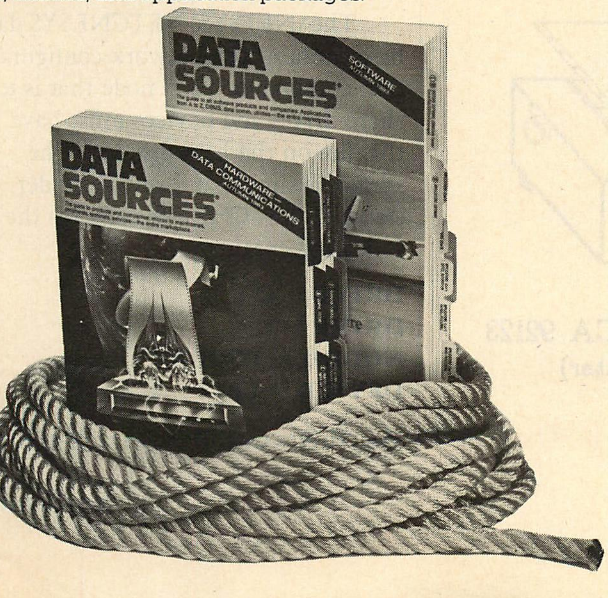

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whether they are for the local PC or for a remote workstation, and then processes the requests accordingly. File protection and record/file locking, if required, are performed during this interception.

A boot diskette must be made for each computer in the network. This diskette contains PC-DOS 2.0 and any desired utilities; the X-NET management program PAXNET.EXE; the X-NET user software; and, optionally, copies of various network data bases. A network administrator diskette must also be prepared. In addition to the user boot diskette programs, this diskette contains the network administrator commands and the X-NET databases NETCNF.SYS, ACCESS.SYS, and NETDIR.SYS. The administrator's utilities and data bases must reside in a special directory called\NETSYS.

The boot diskettes are set up with several batch files that are provided with the X-NET software. The administrator diskette is generated by running INSTALL1.BAT. This produces a bootable diskette, but suggestions are provided in the manual for tailoring the diskette to specific situations. For example, X-NET requires a device driver, DUMDRVR.DVR, to be the final command in the CONFIG.SYS file. This driver installs the software necessary for using all extra drive letters through drive Z. If the administrator wishes to add other device drivers to the system, the CONFIG.SYS file produced by the installation program must be edited.

The\NETSYS\NETCNF.SYS data base contains the network configuration commands. Each node that is to share drives and devices must have this file on the boot diskette. The syntax is simple and easy to understand. If NETCNF.SYS contains the following commands:

DRIVE = C
DRIVE = D
NODE01 = FOOBAR
DEVICE = LPT1

local drives C: and D:, as well as the

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Maximum records/file	100,000,000	65,600	32,800	32,800	32,800
Maximum bytes/record	10,000	1,000	2,400	1,000	255
User must be programmer	No	Yes	No	No	No
Maximum number of indexes automatically updated.	15	1	1	1	1

(Data are taken from most recent versions of programs available to American Planning Corporation, Alexandria, VA)

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local printer, are devoted to the network, and the default hexadecimal name, NODE01, becomes FOOBAR.

As provided, NETCNF.SYS declares the floppy disk drives A: and B: and the devices CON: and PRN: as being available to the network. The manual suggests assigning a meaningful name to each node to replace the default hexadecimal label. If other devices are to be available to other nodes, they must also be declared in this file. Local drives and devices not specifically mentioned are available only to the local user.

No AUTOEXEC.BAT file is included on the diskette. If the administrator wants to add one, some suggestions are made for a simple start-up sequence of commands.

Once the administrator's boot diskette has been created, the network users must be created. This is done under PC-DOS, with the MAKEUSER utility, a simple menu-driven program that prompts for the user and group names and any assigned passwords. Groups are sets of users who can share system resources among themselves without having to share them with the entire network.

The administrator sets up each user with a name, password, and group. The user may change the password at any time with the PASSWORD utility. MAKEUSER can also be used to remove a group or individual from the network. The data entered with MAKEUSER is stored in the ACCESS.SYS data base, which normally resides on the administrator's diskette. The PASSHOLD utility may be used to mark other copies of PAXNET.EXE as "keepers" of the access information.

The user boot diskettes are created with USERCOPY.BAT. Each diskette can contain an optional volume label. If the node is not to be a password filekeeper, the \NETSYS\ACCESS.SYS file should be deleted from the user diskette. The PASSHOLD utility should also be used to mark that diskette's copy of PAXNET.EXE as a non-passholder. A

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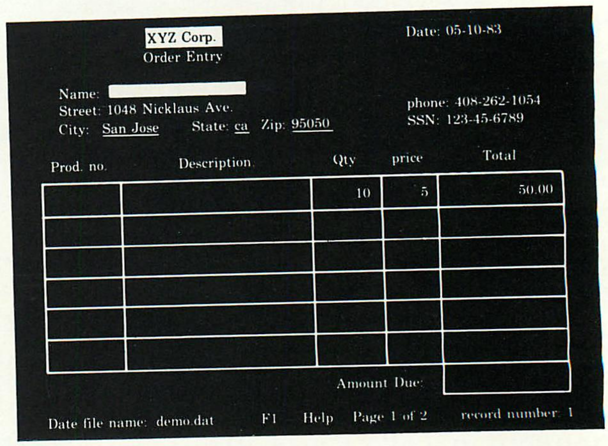

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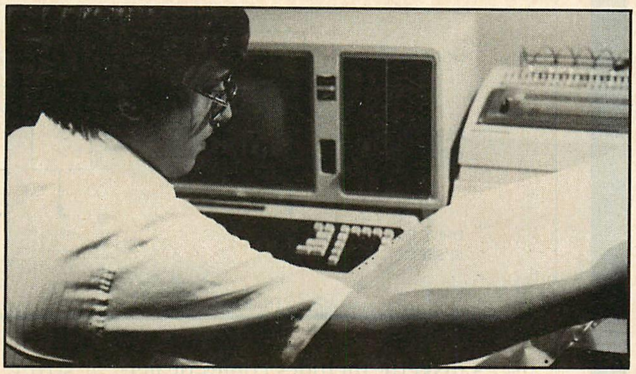

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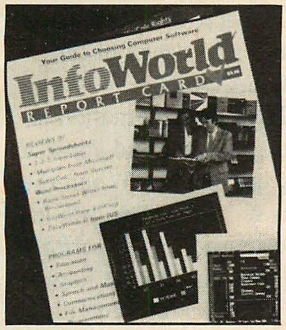

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- Insert Another Disk File
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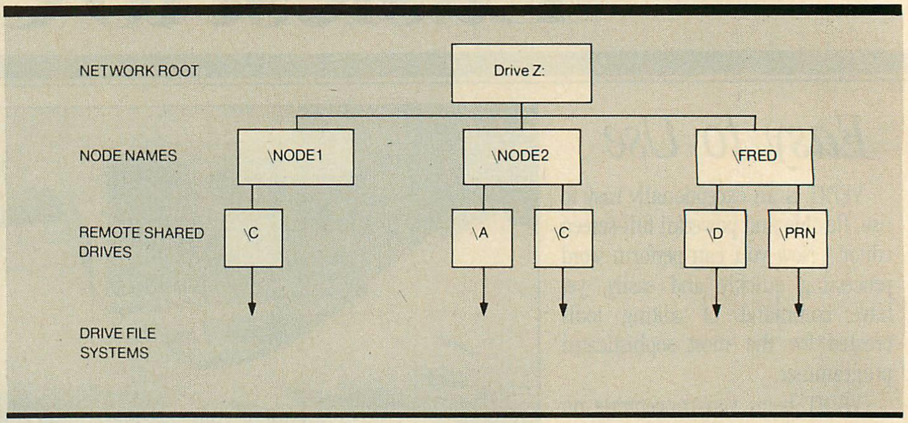
Figure 2 *X-NET's Distributed File System*



user's diskette includes copies of network utilities for logging on and off, changing a password, protecting files, and assigning macros.

X-NET extends the DOS file system across the entire outlying file structure of the network by making the distributed file system appear as the hierarchical file system of a simulated drive Z: (see figure 2). All the shared file resources reside on this drive. Shared drives are accessed with a path name constructed from drive Z:, the node name, and the drive letter, followed by the directory and file name if applicable. For example, the X-NET command

```
DIR     Z:\NODE01\C\SALES
```

would access the directory SALES on the C: drive of NODE01 and

```
COPY
  Z:\PC1\A\THIS.COM   Z:\PC3\
  C\THAT.COM
```

would copy THIS.COM from drive A: of PC1 to THAT .COM on the C: drive of PC3.

Because the path names can become very complex, a utility, MACASGN, is provided to implement string macro substitutions. The command

```
MACASGN F: Z:\PC2\B
```

would assign macro F: to the string Z:\PC2\B. Whenever X-NET sees the string "F:" it will substitute the string Z:\PC2\B. MACASGN is used for assigning logical drive letters (all letters A through Z are allowed) to specific drives at remote stations. A set of default macro assignments is most conveniently placed in the AUTOEXEC.BAT file.

The X-NET documentation is unclear about the uses and abuses of MACASGN commands. When the network was set up at the *Tech Journal*, we experienced severe performance problems and erratic network behavior. The problems were ultimately traced to incorrect usage of MACASGN involving limitations that had not been mentioned anywhere in the X-NET manual. In particular, it is impossible for a shared node to MACASGN its own devices over the network.

MACASGN commands must be used with care at a station that is sharing disk drives or peripherals. For example, a remote station that wants to access the ADMIN subdirectory on node PC2's drive C: can MACASGN "F:" to Z:\PC2\C\ADMIN, but the same assignment at node PC2 causes performance problems. If PC2 wishes to MACASGN "F:" to the subdirectory ADMIN on its drive C:, it must be done with the "local" syntax:

```
MACASGN F: C:\ADMIN
```

Remote devices can be accessed with

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X-NET by specifying the device in a pathname, which includes the prefix \DEV\. The command

COPY B: THISFILE.WP Z:\PC3\DEV\LPT1

would copy the file THISFILE.WP from the local B: drive to the remote printer LPT1: attached to PC3:. This process can be eased considerably by using the MACASGN assignment

MACASGN LPT1: Z:\PC3\DEV\LPT1

When the local station specifies LPT1: as the receiving device, the document will be routed to the remote printer.

There were several bugs in the X-NET software that warrant mentioning. First, DOS 2.0 I/O redirection doesn't work when the network is installed. Commands that make use of pipes and filters thus do not function under X-NET. Second, internal system commands, such as DIR and COPY, when executed on the shared hard disk, will lock out anyone attempting fixed disk access, displaying this message:

NOT READY ERROR ON DRIVE Z: ABORT/RETRY/IGNORE

If this error is produced, it is sometimes possible to retry and have the command be successfully completed. However, we had at least one case of a complete system hang-up at a user station that attempted to access the shared node while it was typing a long file to the console.

Several extended function calls are provided for application programmers and system developers. There are three locking calls: RLOCK (read only lock/unlock), RWLOCK (read/write lock/unlock), and WATCH (monitor a specific range in a file for changes). In this locking approach, the application program specifies the complete path and file name, the starting byte of the segment within the file to be locked, and the length of the segment to be locked. X-NET will check for simultaneous lock requests of the same file. If a conflict is found, the second lock request is rejected. It is the responsibility of the programmer to provide a retry algorithm. WATCH allows distributed applications to determine, when a lock call is issued, whether the segment involved has been changed since it was last accessed.

Protection Facilities

X-NET provides both network access protection and three levels of file protection. These facilities are normally implemented by the network administrator, although any directory or file owner can change the associated protection. X-NET maintains a table of valid user names, along with their corresponding passwords and group names, if any. Each name is assigned a user number and each group is given a group number for internal use.

There were bugs in the X-NET software. First, DOS 2.0 I/O redirection doesn't work when the network is installed. Commands that make use of pipes and filters thus do not function under X-NET. Second, internal system commands, when executed on the shared hard disk, will lock out anyone attempting fixed disk access.

Each file and device has an associated owner. X-NET uses five bytes within a directory entry to record the ownership and protection information. The protection field specifies read/write authorizations assigned to the file's owner, his or her group, and the generic ALL, which is everyone in the network. The file-ownership field records the owner's user and group number. Only the administrator and the owner are allowed to change the protection status of an object or write to this field, unless explicitly overridden with the PROTECT command. The protection status of files and subdirectories can be listed with the XDIR command.

For all the protection command and status displays, the protection status is specified by a set of six characters enclosed in square brackets:

```
ALL    GROUP   OWNER
[ WR    WR      WR ]
```

Each WR represents protection status for one of three levels. If a file's ALL status is set to read or write access, anyone on the network can access it for that purpose. If read or write is granted to the owner's group, only group members have the assigned privileges. Otherwise, only the network administrator and the owner have the assigned access. If the position is occupied by a letter, access is allowed by the corresponding level; if the position contains a dash, that access will be denied. For subdirectories, the protection status of the write operation determines who can create, erase, or rename files within that subdirectory. The status of the read privilege determines who can read the contents of the directory with DIR, reference it with CHDIR (CD), or open files within it. The command

PROTECT C:\SALES\FROGS.DAT [---RWR]

would set the protection status of the files FROGS.DAT to read/write for the file owner and read only for the owner's group. No one else would be able to access the file for reading or writing. The command

PROTECT B:\ADMIN\BATS [-R-R-R]

would allow ALL, the group, and the owner to read the subdirectory BATS in the directory ADMIN; no writing would be allowed.

When a new file is created, it is automatically assigned a default value associated with the node on which it

Figure 3 XDIR Listing

Volume in drive B is FOOBAR
Directory of B:/

IBMBIO	COM	0	1/01/80	12:05a	[wrwrwr]	<0,0>
IBMDOS	COM	0	1/01/80	12:05a	[wrwrwr]	<0,0>
COMMAND	COM	17664	9/09/83	11:17a	[wrwrwr]	<0,0>
INSTALL2	BAT	975	1/05/83	7:46p	[wrwrwr]	<0,0>
FUMBLE	COM	849	1/06/84	10:19a	[--wrwr]	<0,0>
FEEBLE	EXE	678	1/05/83	7:23p	[-----r]	<0,0>
FOIBLE	BAT	505	1/05/83	7:24p	[wrwrwr]	<0,0>
FARKLES	BAT	554	1/05/83	7:22p	[---rwr]	<0,0>
FIMBLE	COM	74	1/05/83	7:48p	[-r-r-r]	<0,0>

9 File(s) 337920 bytes free

was created. The default values are created by the administrator, but both the owner and the administrator can use the PROTECT utility to change this value. An owner can establish a default protection status by calling PROTECT with a /D parameter. The command

PROTECT/D [----RW]

would create a default protection status allowing read/write access for the owner only and no access for anyone else. The protection status of files can be listed by using the XDIR command (see figure 3).

To have full use of network resources, a user must log in with the ACCESS command. A user may access the network as a local user without logging in. However, a local user can access only network resources whose protection status has been assigned as ALL. All files and subdirectories created by a local user are owned by whomever is currently logged into that station.

ELECTRONIC MAIL

An elegantly designed electronic mail package called X-MAIL is available separately for $595. It is easy to use and provides stations with an easy method of passing files and messages around the network.

Before the mail program can be used, the administrator must set the system parameters, such as user names and passwords, with the XMAILU utility program. Once this information has been entered, any defined user may run XMAIL.

XMAIL makes extensive use of function keys. The key assignments are always visible on the bottom line of the display. When XMAIL is invoked, the use is informed if there is new mail. If so, the first new message is displayed on the screen; otherwise, the most recent message is shown. From the initial prompt line, the user can opt to answer or discard a particular message or to read the next/previous one. A search facility is also provided at this level; a keyword or name can be selected and a trace instituted to find all messages regarding any subject or correspondent.

If the user chooses to answer an old letter or compose a new one, XMAIL will invoke the message editor. While not an elaborate word processor, the editor is easy to use. It automatically provides a message ID and prompts for header information, such as the recipient, to whom the message should be copied, the subject, and any keywords. The keywords are used to do message traces from the first level of XMAIL. The header can be edited later on if required. The completed message is sent as regular mail or delivered with priority. Once sent, a message cannot

Table 1 *X-NET Benchmarks*

	PC-DOS 2.0	1 user user stn.	1 user shared stn.	2 users user stn.	2 users shared stn.
I/O BENCHMARKS (in seconds)					
random access	6	10	10	30	21
sequential read/write	29	46	45	99	78
sequential read	14	21	21	37	36
dBASE sort, 1 key	40	55	56	92	82
dBASE Index, 1 key	29	51	50	126	101
WORD PROCESSOR BENCHMARKS					
WordPerfect:					
load wp from hard disk	4	8	6	13	11
load wp from floppy disk	14	17	14	15	17
exit wp (to hard disk)	1	3	3	4	5
load file from floppy	4	5	5	5	6
save file to floppy	18	20	21	21	21
load file from hard disk	2	4	2	4	4
save file to hard disk	15	17	16	21	20
WordStar:					
load wp from hard disk	6	10	7	11	11
load wp from floppy disk	7	10	9	9	9
exit wp (to hard disk)	0	1	1	1	1
load file from floppy	3	6	5	15	13
save file to floppy	32	35	33	36	35
load file from hard disk	3	11	7	15	14
save file to hard disk	10	45	22	64	46

be retrieved even if it has not yet been "opened" by the recipient.

Although on-line help is available, it is not very extensive. Pressing the help key (F1) elicits an AMBIGUOUS COMMAND message, followed by a list of suggested commands to try instead. The FIND command also generates a curious response. It displays the AMBIGUOUS COMMAND message and offers the user a choice of commands beginning with SELECT. This is mildly inconsistent and is the only confusing aspect of XMAIL.

PERFORMANCE

We tested X-NET with six small benchmark programs designed to view network performance with a heavy I/O load (see table 1). The random-access test writes 50 records, within a thousand-record file, to 50 other records. Each record is 50 bytes long. The sequential-read test reads 641 lines, each 50 bytes long within a 40,000 byte file. The sequential read/write test reads and then writes 641 lines, each 50 bytes long, to another file. The dBASE II benchmarks used 200 records, each containing fields for a name, address, telephone number, and zip code. These records were sorted on one key, indexed on one key, and indexed on two keys. The word processor benchmarks used WordStar and WordPerfect, in conjunction with a 30,000-byte file.

The programs were run under several different conditions, with the X-NET hardware always *in situ*, except for the control tests in the standard single-user PC-DOS environment. One node, a PC with 256K memory and an Epson RX-80 printer, was termed the user machine. The shared unit was an IBM PC/XT with 640K memory, a 10-megabyte fixed disk, and an Epson FX-80 printer. The single-user tests were first done on each unit, while the second computer stood idle. Next, the tests were performed with both computers simultaneously running the benchmarks from different volumes on the shared hard disk drive.

Although the performance of X-NET was disappointing in relation to its ease of use and elegant design, it is important to remember that these tests represent the best and worst cases.

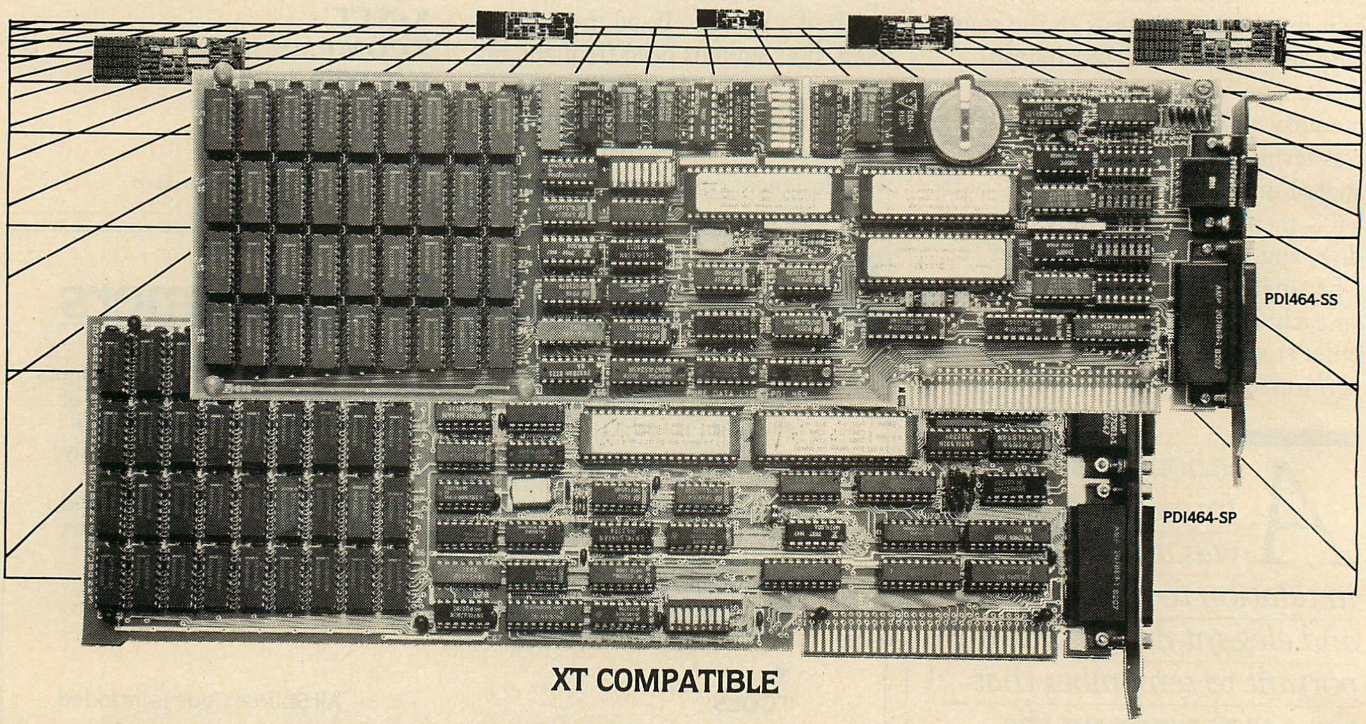
Under PC-DOS alone, the random-access test took 6 seconds, the sequential read/write test 29 seconds, and the sequential-read test 14 seconds. Performance declined by half when the tests were run on a single station running the X-NET software. When two users performed these tests simultaneously, the performance degraded even more, to about one-third of the PC-DOS results. The X-NET software had approximately the same effect on the dBASE II tests as on the random-access and sequential-read tests. Similarly, performance was seriously affected with all of the word processor benchmarks that accessed the shared hard disk. Tests using a floppy diskette showed less severe performance degradation.

Although the performance of X-NET was disappointing in relationship to its ease of use and elegant design, bear in mind that these tests represent the best and worst cases. Users who need infrequent access to a shared hard disk will not sustain much of a penalty. If, on the other hand, user stations need frequent and heavy I/O across the network, the time delays may become an important factor. For offices that require a well-designed, cost-effective product for light networking needs, X-NET is definitely worth investigating.

X-NET
XCOMP, Inc.
7566 Trade Street
San Diego, CA 92121
619-271-8730

CIRCLE 495 ON READER SERVICE CARD

Plug Pure Data



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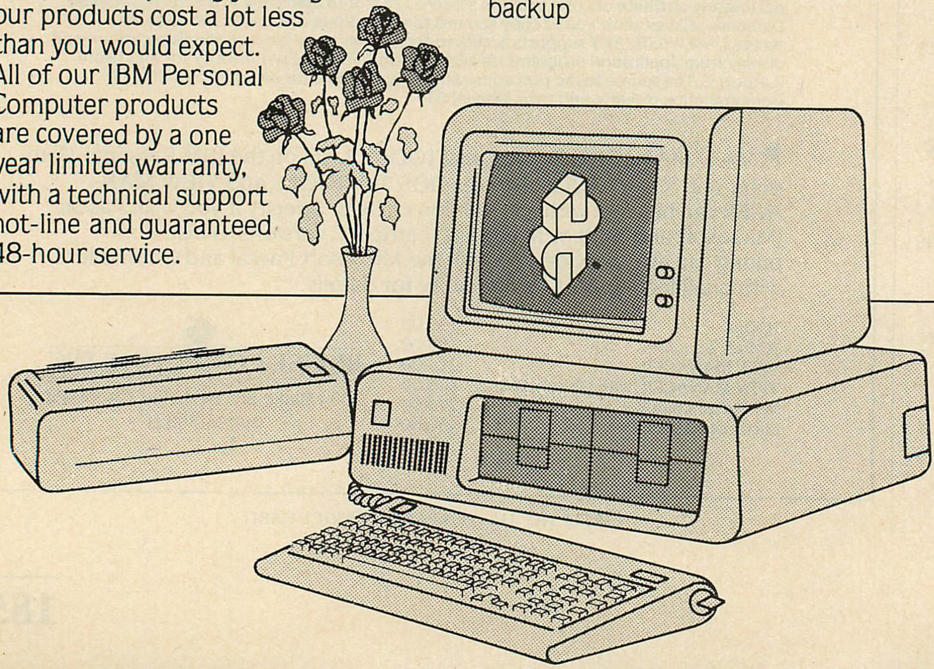

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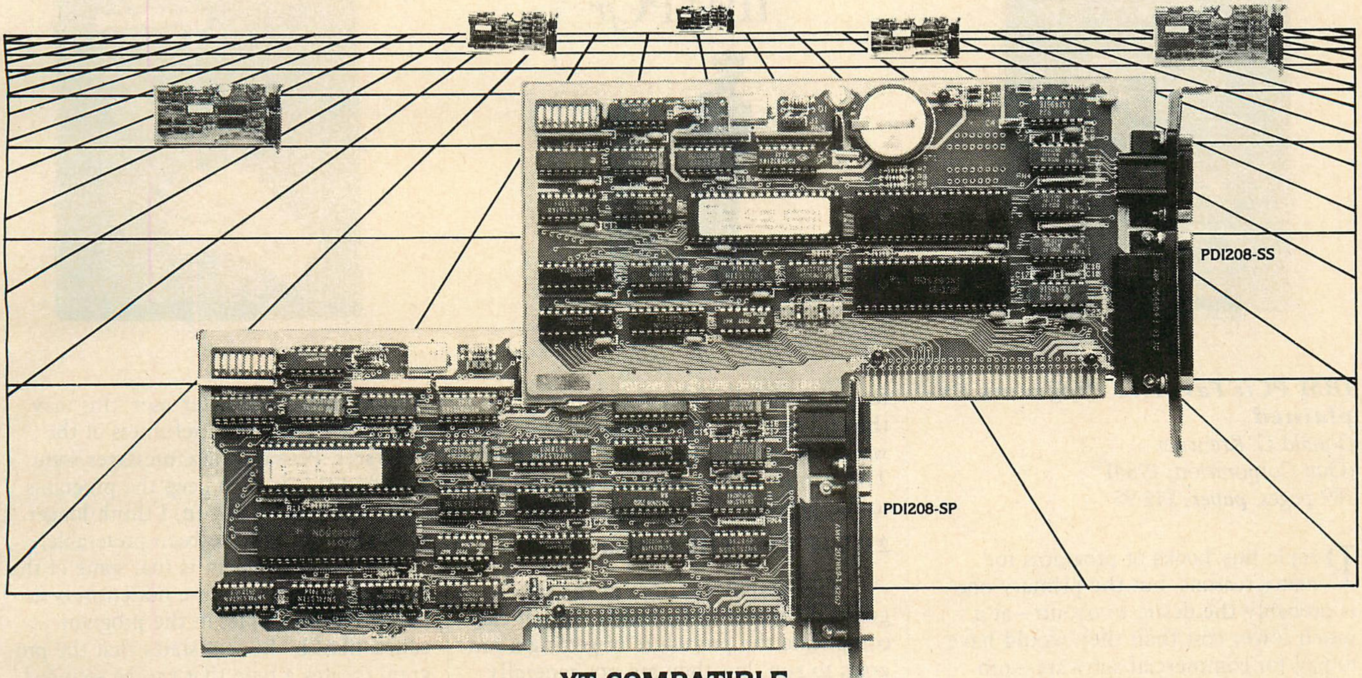

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- Fully-illustrated installation and operation manual

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- Only occupies one expansion slot
- Fully-illustrated installation and operation manual

PDI208-SS

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- Real Time Clock/Calendar with field-replaceable lithium battery backup
- p-Disk™ disk emulator for single/double-sided diskette emulation
- Print spoolers for parallel and serial channels with multiple copies
- Software for clock support, dynamic memory configuration, memory testing
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CIRCLE NO. 190 ON READER SERVICE CARD

IBM PCjr Favorite Programs Explained
Donald C. Kreutner
(Que Corporation, 1984)
189 pages, paper, $12.95

People buy books of programs for many reasons, but the primary one is probably the desire to obtain—at a much lower cost than they would have to pay for commercial software—programs that perform a variety of useful and/or entertaining tasks. The value of a book of this type, therefore, depends mostly on the types of programs included.

In this respect, *IBM PCjr Favorite Programs Explained* will satisfy most of its purchasers. It contains a wide variety of BASIC programs, from games to business applications. Although these programs will not substitute for most complex commercial software, they will probably be adequate for PCjr owners who need only a few simple home management or educational programs.

The programs in this book are divided, somewhat arbitrarily, into four categories. The first chapter covers math and problem-solving programs, the second includes games and miscellaneous programs, and the third covers business and educational programs.

Most of these programs perform tasks that are useful in many situations. Some, such as the basketball statistics program in chapter 1, are fairly specific and would be difficult to adapt to other uses, but most are more general. They seem to run predictably, although there are a few surprises. For example, in the Hangman program the user can choose either a one-player or a two-player mode. In the two-player mode, when one player has guessed his word or both players have been hung, the program displays a message and the two correct words. In the one-player mode, the program asks for only one player's guesses, but at the end of the game it displays two words, as though there were two players. This can be eliminated by adding a line to the program:

```
2355 IF P=1 THEN 2360
```

Typographical errors in the programs do appear occasionally, which can complicate the procedure of getting a program to run, but they are not generally difficult to spot if the user has some familiarity with BASIC.

One of the strengths of this book is that it can help novice BASIC programmers expand their knowledge and improve their skills. One way in which this is accomplished can be frustrating. Because it is nearly impossible to avoid making typographical errors when keying in programs, the user will almost certainly have problems the first time he tries to run one of them. Analyzing why the problems occur and then fixing them is an excellent way to learn how the programs work.

Another way to improve BASIC programming skills is by modifying programs. Most of the routines in the book could easily be adapted to suit a user's particular needs, and many of them could be used as parts of larger programs. The author has written the book with this in mind. He suggests some possible changes; many others will undoubtedly be evident to the user by the time he has the program running correctly.

One modification that I would find necessary involves the user interface. The messages that appear on the screen when a program is running should be expanded and clarified. As the author has presented them in the book, they are cryptic to the point of incomprehensibility. It is sometimes necessary to refer to the program descriptions and to the programs themselves to understand what response a particular prompt needs. For an inexperienced computer user, this may seriously impair the usefulness of the programs. Perhaps these messages were designed this way to keep the programs short and easy to key in; I think longer programs would have been preferable.

Another problem is that some of the program descriptions are not entirely accurate. For example, in the program called BEEP1, the text states that the program creates a tone that can be sounded at any pitch, any level of loudness, and for any duration; the user is supposed to be able to select these parameters as the program runs. In fact, the program asks the user to input information only about the duration of the tone.

In summary, many PCjr owners will find this book useful, if they are willing and able to make some modifications to the programs included in it. Users can improve their BASIC programming skills and, at the same time, obtain some helpful, personalized programs. Using this book is not as easy as inserting a commercial software diskette into a drive, but for the price, it's easy enough.

—Barbara Tilly

Introducing IBM PCjr
Douglas Ford Cobb and Chris DeVoney
(Que Corporation, Indianapolis, 1983)
245 pages, paper, $9.95

IBM's announcement of PCjr has fostered intense competition among publishers of computer-related media, each publishing company striving to be the first to produce materials for the new market. An early entry in this race was Que Corporation's *Introducing IBM PCjr,* which was published in December.

The most useful sections of the book are probably those that focus on specific hardware components, applications software, and comparisons of the PCjr with

other home computers and the IBM PC. Possible system configurations are outlined in one chapter, including current price information and reasons for buying each piece of equipment. Also considered are possible future expansions from IBM and other hardware and software companies. The information in these chapters is important for prospective PCjr buyers.

It is probably such prospective buyers who will get the most out of this book. Buyers who know little about computers will gain at least enough familiarity with terminology to be able to understand a computer salesman, and the later chapters of the book will help them decide what they need in a home computer and whether PCjr will meet those needs.

Prospective buyers with more computer experience will find less of value in this book, but the discussions of the differences between PCjr's hardware and that of other home computers, including the IBM PC, will help them determine whether PCjr is capable of supporting their intended uses.

The book's greatest problem is related to its intended audience. The authors state that the book is meant for anyone interested in PCjr, novices and experienced computer users alike. Their attempts to meet the needs of both audiences often confuse the focus of the discussions. Much of the book is aimed at the computer novice, particularly at families entering the home computer market for the first time. This approach seems sound, since IBM is marketing the machine to appeal to that audience.

The first chapter, entitled "Overcoming Fear and Uncertainty," is clearly directed to inexperienced users. It discusses basic computer concepts and terminology, offering helpful analogies and examples. Unfortunately, a number of terms that are used later are not defined in this section. For instance, in the chapter on DOS 2.1, the authors say that it is necessary to reboot PC DOS in order to free the memory used by the command GRAPHICS. Several paragraphs later, they state that the computer must be reset to free up the space used by the PRINT command. Although anyone familiar with computers would know that rebooting PC DOS and resetting the computer involve the same actions, a novice would probably not know this. He might figure it out several pages later, when the process of doing a system reset is described, but an earlier discussion would have avoided the confusion entirely.

The chapters on DOS 2.1 and on languages for PCjr also reflect the difficulty in writing for both novices and experienced users. Much of the information presented is too technical for the inexperienced user to understand without more detailed discussion, yet there is not enough technical depth in the descriptions to satisfy a more expert reader.

For example, the authors attempt to give a quick summary of BASIC, presumably in order to help clarify for a novice the discussion of the differences between the various types of BASIC available on PCjr. It is important to know that these differences do exist, but the details are probably better left for other texts; no condensed summary of BASIC will be sufficient to keep someone who doesn't know that language from being bored and confused by discussions of such details. This section of the book, as well as that on DOS 2.1, should probably have been shortened to cover only the basics of each topic as it relates to PCjr.

Overall, the book would have been more useful had it aimed more consistently at the novice. Combined with visits to computer stores along with other research, however, this book can provide useful information on which to base a purchase decision.

—BT

Introducing the IBM PCjr®: Unshelling the Peanut
Andrew M. Seybold
(Howard W. Sams & Co., Indianapolis, 1983)
16 pages, index, glossary, paper, 12.95

The advertising copy on the back of this book claims that it is "required reading before you buy your PCjr, and a handy reference guide once you own one." Although I often feel that advertising copy exaggerates the products it touts, in this case it's right on the mark.

The book explains nearly everything a novice user would need to know before purchasing a PCjr, including what the system's components and optional additions do, how they differ from those on other comparable products on the market, and how to choose which components to buy. There is also a clearly presented discussion of the differences between the PCjr and the PC and XT.

Once he has purchased a PCjr, the novice user can refer to this book for detailed help in setting the system up, using the keyboard (there is a whole chapter on how this keyboard works and how it can be programmed, using BASIC and DOS, and communicating with other computers through a modem. The discussions on using BASIC are especially useful, focusing on the differences between cassette and cartridge BASIC and covering briefly those features of cartridge BASIC that are not included in advanced BASIC for the IBM PC. There are clear explanations of the equipment and commands needed to save, load, and run programs in the various versions of BASIC. Many books, including the BASIC manual for the PCjr, provide this information in a confusing, dislocated way, apparently assuming that the rules for these procedures are more obvious than they may appear to the novice.

One of this book's strong points is that it is consistently directed toward the novice computer user. No attempt is made to present detailed BASIC programming procedures, for example, but enough information is provided that an interested reader will be encouraged to seek out books on the subject. One problem with many books written for the novice is that their authors seem to "talk down" to the readers. Seybold (who is also the author of the well-regarded *Seybold Report*) doesn't do this. The tone is straightforward, informative and friendly, and the pace is fast enough to keep even more experienced users interested.

For readers who want more technical information, there are several appendices containing details on topics mentioned briefly in the main body of the book. These topics include infrared communications (especially as used in the PCjr keyboard), RS232C serial communications, communications protocols, and the components of the motherboard.

Another strength this book has is its illustrations. There are many photographs, tables, and figures accompanying the text, and nearly all of them are useful and attractive. For example, there is a table that compares the major features supported by the PCjr, the PC, and the XT. Other figures help explain how to connect various devices to the computer, clarifying the discussions.

The only negative comment I have to make about the book is that it could have profited from a good editing and proofreading job. Although there are few ungrammatical sentences, there are many that are awkward, and there are so many typographical errors throughout the text that it is annoying. These are not major problems, but a book as good as this one deserves to have nothing that distracts the reader from the subject matter.

This book will be valuable both for people who are planning to purchase a home computer and for those who already have a PCjr and want to know what to do with it. If I could buy only one of the books I've seen so far on the PCjr, this would be it.

—BT

TECH NOTEBOOK 17

Name, Rank, and Serial Number

To set machine-specific parameters from inside a program, it helps to know the machine part number, copyright date, and ROM BIOS date.

SUSAN GLINERT-GOLE

The November 1983 IBM Personal Computer Seminar Proceedings states that the second-to-last byte in the ROM BIOS indicates whether the current machine environment is an IBM PC, an IBM PC*jr*, or an IBM PC/XT. An FDh indicates the machine is an IBM PC*jr*, FFh indicates an IBM PC or an early IBM PC/XT, and FEh indicates a later model IC/XT. This information is useful to system developers who need to set machine-specific parameters from inside of a program. Although this byte will definitely distinguish between a PC*jr* and its bigger brothers, it does not always reliably distinguish between a PC and a PC/XT. *Tech Journal*'s PC/XT is an early model and the identification byte at FFFFEh is FF. The program below interprets this byte as indicative of an IBM PC.

Occasionally, as a matter of utility or curiosity, a programmer would like to know the machine part number, copyright date, and ROM BIOS date. The following BASIC program looks in the appropriate ROM BIO locations and prints out the identification byte at FFFFEh, the serial number and copyright date at FE000, and the ROM BIOS date at FFFF5h.

We ran the ROMREAD program on the machines around *Tech Journal*'s office and on two of the staff's home computers and found four different ROM BIOS copyright dates, in addition to two different part numbers for IBM PCs of various pedigrees (see table 1).

MACHINE	ROM BIOS DATE	COPYRIGHT DATE	PART NUMBER
IBM PC	10/27/82	1982	1501476
IBM PC	10/27/82	1982	1501476
IBM PC	10/27/82	1982	1501476
IBM PC	4/24/81	1981	5700051
IBM PC/XT	8/16/82	1982	5000026
IBM PC*jr*	6/1/83	1981, 1983	1504037

Table 1: Results of Running ROMREAD.BAS on *Tech Journal* machines

Listing 1 ROMREAD.BAS

```
100 ' This program will print the copyright date,
110 ' ROM BIOS date, and machine type
120 ' Author:  Susan Glinert-Cole
130 '
140 PROG$ = "Signature V1.01 19Feb84"
150 CLS: KEY OFF: PRINT PROG$: PRINT
160 '
170 ' Part 1:  Get copyright date
180 DEF SEG = &HFE00: A = 0: B = 30
190 PRINT "ROM Location FE000:  ";
200 GOSUB 380
210 '
220 ' Part 2:  Get ROM date
230 DEF SEG = &HFFFF: A = 5: B = 12
240 PRINT "ROM BIOS date is:    ";
250 GOSUB 380
260 '
270 ' Part 3: get the machine type, byte at FFFFEh
280 DEF SEG = &HFFFF
290 ID.BYTE = PEEK(&HE)
300 ID$ = ""
310 IF ID.BYTE = &HFF THEN ID$ = "PC"
320 IF ID.BYTE = &HFE THEN ID$ = "XT"
330 IF ID.BYTE = &HFD THEN ID$ = "PCjr"
340 PRINT "Machine type is:     ";
350 IF ID$ = "" THEN PRINT "Unknown.  Code is ";HEX$(ID.BYTE)
              ELSE PRINT "IBM ";ID$
360 END
370 '
380 ' Subroutine to get the string from memory,
390 ' convert unprintable characters, and print it.
400 P$ = ""
410 FOR X = A TO B
420   C$ = CHR$(PEEK(X))
430   IF " " > C$ OR C$ > "~" THEN C$ = " "
440   P$ = P$ + C$
450 NEXT X
460 PRINT P$
470 RETURN
```

Other Books on PCjr

Discovering the IBM PCjr
Peter Norton
(Microsoft Publishing; Bellevue, WA; May, 1984)
320 pages, paper, $15.95.
This is a step-by-step introduction to the PCjr, including information on what it can do and how to create programs.

Exploring the IBM PCjr
Peter Norton
(Microsoft Publishing; Bellevue, WA; April, 1984)
336 pages, paper, $18.25
This offers a more in-depth look at the PCjr, covering the machine's inner works, including the chips it uses and how they affect its operation.

Mastering the IBM PCjr
Peter Norton
(Microsoft Publishing; Bellevue, WA; July, 1984)
352 pages, paper, $19.75
This is a programmer's reference guide to the PCjr, including relevant information on Pascal and C, as well as a detailed look at the machine's built-in ROM.

PCjr BASIC Programs for the Home
Andrew Bartorillo
(Banbury Books; Wayne, PA; April, 1984)
272 pages, paper, $14.95
Included in this book are programs to help users balance checkbooks, compute mortgage payments, etc. Each program is accompanied by a description of what the BASIC code is designed to accomplish.

Sound and Graphics for the IBM PCjr: Fun and Creativity with IBM's Newest Home Computer
Timothy Orr Knight
(Banbury Books; Wayne, PA; May, 1984)
256 pages, paper, $14.95
In a conversational, nontechnical style, this book explains how to draw three-dimensional pictures, play familiar melodies, etc., using BASIC.

Erratum: *Many a* Tech Journal *reader noticed the mistake we made in last month's Book Reviews: we did not illustrate the review of Willen and Krantz's* 8088 Assembler Language Programming: The IBM PC *with a photograph of their book. Pictured instead was the cover of another book,* IBM PC Assembly Language: A Guide to Programmers, *by Leo J. Scanlon and published by the Robert A. Brady Co. Our apologies to publishers, authors, and readers.* **—WF**

TECH NOTEBOOK 18

Using a Switch-Type Joystick on the IBM PC

A method for getting switch-contact speed in resistive environments

SCOTT MCCANN

The two types of joysticks used with most games and computers are the switch type (Atari, etc.), which closes a set of contacts when the stick is pushed top-bottom-left-right; and the resistive type (Color Computer, etc.) in which sticks turn pots as they are pushed top-bottom-left-right.

Both of these types are fine in a situation for which they were designed, but problems arise if the computer, joystick, and program were all designed by different people. The IBM PC uses the resistive type of stick, which causes problems when a user runs a program, like PC-MAN, that requires quick movements.

I purchased a nice "professional" type joystick for $10 at a local computer fair, and Fair Radio (P.O. Box 1105; Lima, OH 45802) sells a similar one for $7.95 (#JS-4P-2P). The joystick I bought had SPDT microswitches at the top, bottom, left, and right. I worked out the following method to use it with the IBM and similar machines giving switch-contact quickness in a resistive environment.

The resistive stick has a vertical pot that shows a short between pin 1 and pin 6 on the IBM Joystick plug (see page 2-121 of the IBM *Technical Reference*) in the up position and 100k ohms between them in the down position. The horizontal pot shows a short between pin 1 and 3 in the left position and 100k ohms in the right position. Dead center shows 50K ohms each way. Joystick *B* on the same connector is similar, using pin 9 as common, pin 11 for horizontal, and pin 13 for vertical. Joystick buttons are pins 2 to 4 for joystick *A*, and pins 10 to 12 for joystick *B*; both buttons are normally open. PC-MAN uses joystick *A*.

In my schematic (figure 1), I connected "1" to pin 1. The other end was connected both to pin 3 (for horizontal control) and to pin 6 (for vertical control). This system requires two circuits for full control. Taking horizontal control as an example, on "left stick" S1 closes, giving zero ohms for full left; on "center" S1 is open and S2 is closed, putting R1 and R2 in parallel for 50K ohms. When the stick is put "full right," contact S2 opens, giving the maximum right signal (100K ohms) to the computer. Vertical control is identical, being wired for short on full up, 50K on center, and 100K on down. The button normally is open.

I have included a simple program to test the joystick conversion. When the routine is RUN a small (hi-res) dot will appear in the center of the monitor. As the stick is moved the dot draws a figure, much as figures are drawn on a child's etch-a-sketch game. Pressing the button will erase the screen. This program is intended as an illustration of the stick's capability rather than as a complete program.

This stick allowed me to double my average PC-MAN score. When this new power is realized it should add even more to the popularity of the PC.

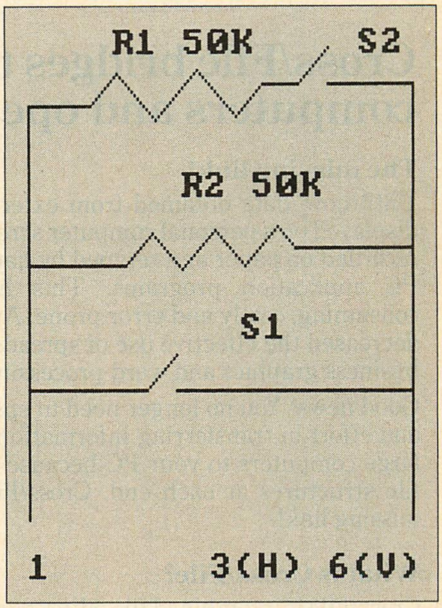

Figure 1: Schematic of Joystick Circuit Set-up

Scott McCann teaches photography in a community college in Annapolis, Maryland.

LISTING 1: ETCH.BAS—PROGRAM TO TEST THE JOYSTICK CONVERSION

```
10 CLS:KEY OFF:SCREEN 2
20 H=320:V=100
30 TEMP = STICK(0)
40 X= STICK (0):Y = STICK(1)
50 IF X < 30 THEN H=H-1
60 IF X > 75 THEN H = H + 1
70 IF Y < 30 THEN V=V-1
80   IF Y > 75 THEN V=V+1
90 IF V>200 THEN V=0
100 IF V<0 THEN V=200
110 IF H>640 THEN H=0
120 IF H<0 THEN H=640
130 PSET(H,V)
140 STRIG(0) ON
150 ON STRIG(0) GOSUB 170
160 GOTO 30
170 RETURN 10
```

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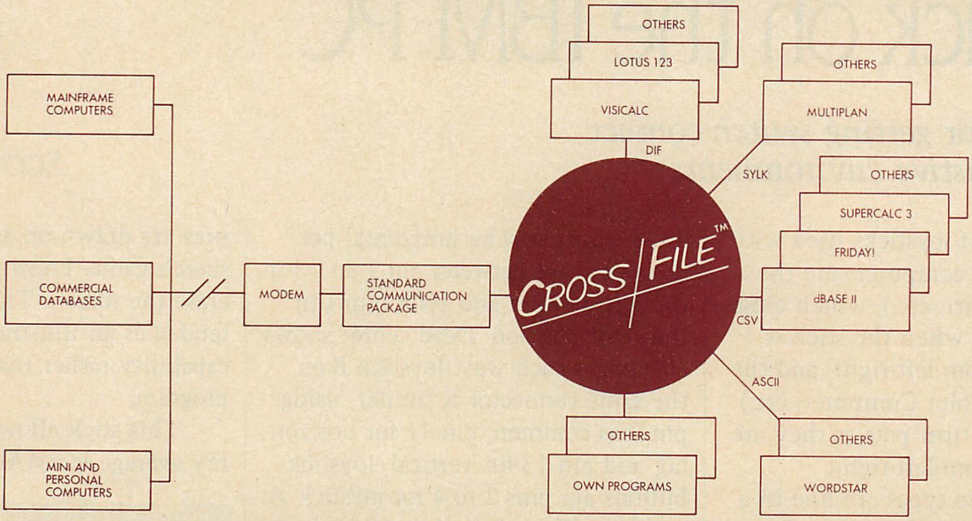

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Simply pick and choose

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Who is Cross/File for?

Cross/File is of value to any PC user who wants to:

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- Create intermediate files, for example by selecting certain entry categories (columns) and certain records (rows) and including them in a new file.
- Exchange information between such programs, such as taking figures out of a table in a word-processing text file and using it as input to a spreadsheet program.

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Sony Versus Universal Studios: So What?

What the Supreme Court's decision might mean to the computer industry

MAX STUL OPPENHEIMER

If the name Willis Griffiths is already familiar to you, you probably have read the *Sony v. Universal Studios* case carefully and should skip to the "So What?" section of this column. Otherwise, the following information may interest you.

In 1976, Universal and Walt Disney Products (the plaintiffs) sued Sony Corporation (manufacturer of Betamax Video Tape Recorders), its subsidiary Sony Corporation of America, four retailers of Betamax VTRs, and Willis Griffiths, a Betamax owner (the defendants). The plaintiffs claimed that some Betamax owners taped some of the plaintiffs' copyrighted movies off the air and that Sony was therefore liable for "contributory infringement" of the plaintiffs' copyrights.

Surveys conducted by Sony, Universal, and Disney showed that the primary use of the machines was for "time-shifting": recording a program for later viewing and then erasing it. The trial court concluded that "noncommercial home use recording of material broadcast over the public airways is a fair use of copyrighted works and does not constitute copyright infringement." Sony could therefore not be liable for contributory infringement.

The case then went to the Ninth Circuit Court of Appeals, which reversed the trial court. The Supreme Court issued the final word on January 17, 1984: the verdict was victory for Sony by a vote of 5 to 4.

The precise holding of the Supreme Court was that Sony was not liable for contributory infringement of copyright because the VTR is capable of commercially significant noninfringing uses. The court noted several noninfringing uses:

1. "Authorized time-shifting"—that is, time-shifting that producers of TV shows did not object to.
2. Copying of TV programs in the public domain, either because they are not originally copyrighted or because the copyright has expired.
3. Copying of programs whose owners consented to permit the programs to be copied for home use. There was testimony from several sports commissions, from the National Religious Broadcasters, and from public TV broadcasters that their programming fell into this category.

The Supreme Court also held that even unauthorized time-shifting was a fair use, for three reasons: because "time-shifting for private home use must be characterized as a noncommercial, nonprofit activity"; because it involved the copying of a work that the viewer "had been invited to view in its entirety free of charge"; and because the copyright owners had not demonstrated "any likelihood of non-minimal harm to the potential market for, or the value of their copyrighted works."

Four justices of the Supreme Court dissented. They noted that the copyright statute does not create a general exemption for single copies of copyrighted works made for personal use and that the legislative history of the 1976 amendments indicated that "mere duplication of a copy may constitute infringement even if it is never distributed." The dissenters disagreed with the majority view of fair use, arguing that the use was not for a "socially laudable" purpose, since the copy is made "for the same purpose as the original"—nothing is added to the original, as it is in the case of a scholarly citation of a work. The dissenters also saw potential harm to the copyright holders—a reduction in the market for their works in movie theatres, in tape rentals, and in reruns.

Thus, in the dissenters' view, it was established that VTR owners who used their machines for time-shifting infringed copyright. The dissenters argued that Sony's liability should be based on its advertisements, which promoted their products' ability to tape shows and included "no visible warning that such use could constitute copyright infringement"; liability could also stem from Sony's intent that its VTR be used for off-the-air recording.

The Supreme Court did not address:

1. Transfer of tapes to other persons

Max Stul Oppenheimer is a partner in the law firm of Venable, Baetjer, and Howard in Baltimore.

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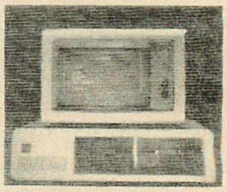

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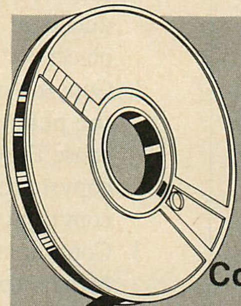

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2. Use of the tapes for public performance
3. Copying of the tapes

So What?
Does the Sony case mean anything to the computer industry? In a technical sense, the case does nothing more than resolve the dispute between the plaintiffs and the defendants. Under Article III, Section 2 of the Constitution, courts have the power to decide only actual cases—they should not render so-called "advisory opinions." However (as you may recall from the January, 1984 issue of *PC Tech Journal*), one of the guiding principles of American law is precedent. There is no American precedent better than the sitting Supreme Court, and the Supreme Court decides such a small percentage of the total number of cases filed in this country that its decisions are routinely scrutinized, not only for their direct precedent value but also for clues as to how other cases might be viewed.

The process is not without risk—sometimes even Supreme Court justices have trouble fathoming their own decisions. Justice Murphy's majority opinion in *SEC v. Chenery*, (322 U.S. 194) begins "This case is here for the second time." Justice Jackson's dissent in the same case begins "The Court by this present decision sustains the identical administrative order which only recently it held invalid." After analyzing the majority opinions in both Chenery cases, Justice Jackson continues candidly, "I give up. Now I realize fully what Mark Twain meant when he said, 'The more you explain it, the more I don't understand it.'"

With that warning, we can look at the Sony case from the point of view of disk drive manufacturers, manufacturers of nibble copiers, users, and software authors.

Sony and the disk drive. Disk drives can be used to copy copyrighted programs, but they have substantial noninfringing uses as well. The Sony court said "the sale of copying equipment [they meant photocopiers, but the logic works for disk drives] . . . does not constitute contributory infringement if the product is widely used for legitimate, unobjectionable purposes. Indeed, it need merely be capable of substantial non-infringing uses." Disk drive manufacturers are pretty clearly safe.

Sony and the nibble copier. Producers of nibble copiers will have to show that there is a substantial noninfringing use for their product in order to escape liability. One possibility would be to ride the coattails of the users' argument described below. In the Sony case, the court reasoned that since users' copying of copyrighted programs for time-shifting was fair use, the manufacturer of the machine that made it possible was not liable for contributory infringement. The trial court even assumed that Sony had constructive knowledge of the possibility that the VTR would be used to record copyrighted programs. However, Sony had the added argument that the VTR was useful for copying public domain programs. Too close to call.

Sony and the user. The Sony case did not focus on the VTR user—the plaintiffs sought no relief against him—but the reasoning does provide some support for the computer user who wants to make archival copies of copyrighted programs. The Supreme Court addressed unauthorized time-shifting and concluded that it was "fair use" and thus not an infringement of copyright, because it was a noncommercial, nonprofit activity that the plaintiffs did not demonstrate would cause "any likelihood of non-minimal harm to the potential market for, or the value of, their copyrighted works." Sounds like the archive copy situation.

There is, however, some language to the contrary in the dissenting opinion. The dissent (and remember there were four dissenters

out of nine justices) noted "neither the [copyright] statute nor its legislative history suggests any intent to create a general exemption for a single copy made for personal or private use" and "the mere duplication of a copy may constitute an infringement even if it is never distributed."

A possibly significant distinction between the Sony case and archival copying is the fact that, in the Sony case, the material copied had already been broadcast, free of charge, to the public—this is obviously not the case with computer programs.

A final word of caution on archival copying: even if it does not infringe copyright, it may violate the license agreement. (Refer to the July/August 1983 *PC Tech Journal.*)

The Sony case specifically states that it does not address the sale of home-recorded tapes. The sale of a copyrighted item, even if "fair use" protected the original copying, would weaken at least one aspect of the Supreme Court's "fair use" analysis—the use would no longer be nonprofit. It would likely impact on the value of the copyright. There are four clear votes against such practices and five justices who have not addressed the issue. Find out what your lawyer's rates are before you do it.

Sony and the software author. Suppose you write and license software. Either you permit archival copying or your license agreement prohibits it and your program is copy protected. End of problem?

Well, maybe not. The Sony decision raises an interesting, if highly theoretical, issue. First, in the Sony case, the court's philosophical view of copyright is that it is to benefit the public; the author's monopoly is granted only to "ultimately serve the cause of promoting broad public availability of literature, music and the other arts." It is "a means by which an important public purpose may be achieved. It is intended to motivate . . . by the provision of a special reward, and to allow the public access to the products of their ge-

nius after the limited period of exclusive control has expired."

Article I, Section 8 of the Constitution gives Congress the power to grant authors limited exclusive rights "to Promote the Progress of Science and useful Arts." If a program is copy protected, how will the public get access after the limited period of exclusive control has expired? (Perhaps they could use nibble copiers—an argument that nibble copier producers could use to support their claim that they should not be liable as contributory infringers.) More fundamentally, if users cannot access the code, has the progress of science and useful arts been promoted?

One simple answer would be that the output is itself the means of promoting science and the useful arts, as well as being accessible to the public. This simple answer poses a difficult question, though.

In footnote 10 of the majority opinion, the Supreme Court quotes the House Judiciary Committee's report on the 1909 Copyright Act as follows: "The enactment of copyright legislation by Congress under the terms of the Constitution is not based upon any natural right that the author has in his writings . . . but upon the ground that the welfare of the public will be served and progress of science and useful arts will be promoted by securing to authors for limited periods the exclusive rights to their writings."

What are "the writings"? Think before you answer. If the writings are the code, then does it not follow that the public should have access to it? If the writings are the output, then does it not follow that the code is not protected by copyright?

Perhaps the question need not be answered since the Copyright Act does not even require publication in order to obtain copyright protection. (Perhaps that means the Copyright Act is unconstitutional.) The question was not before the court, so it is pure speculation, but until it reaches the Supreme Court, it is the stuff of which appellate dreams are made.

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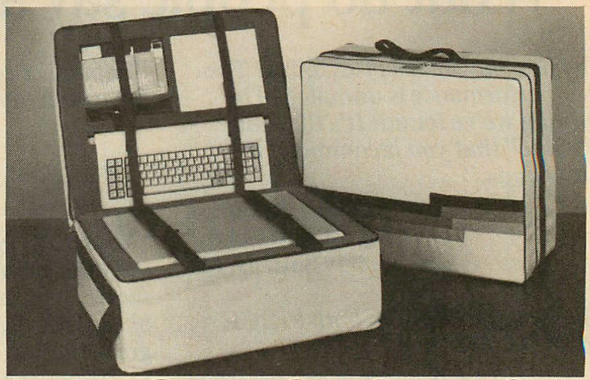

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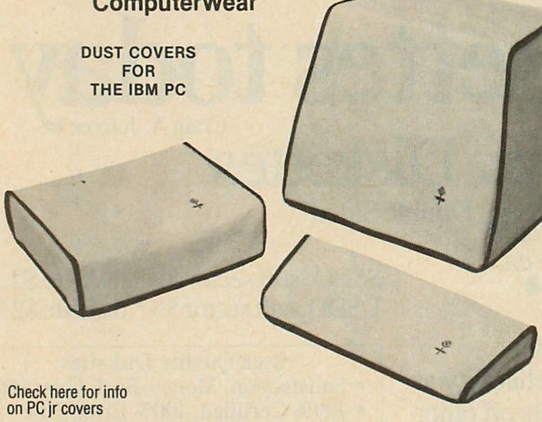

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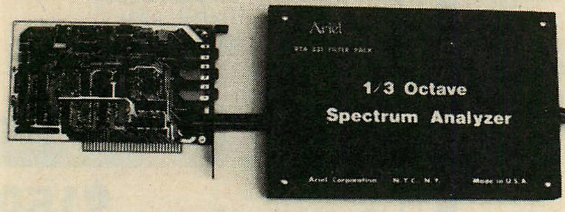

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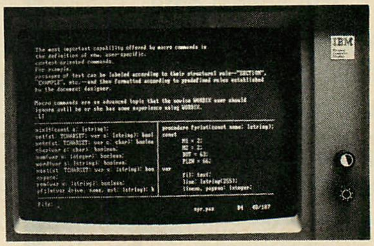

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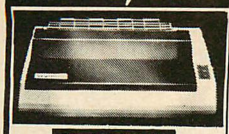

STAR GEMINI

Gemini-10X, 120 CPS, 80 Col., friction & tractor feed, (parallel) .$Call
Gemini-15, above w/15" platen.Call
Delta-10, New! Like 10-X but with a faster speed of 160 CPS $Call

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FX-80, 160 CPS, 80 Col., friction & tractor feed, parallel ...... Call
FX-100, 160 CPS, 132 Col., friction & tractor feed, parallel ..... Call
RX-80, MX-80 F/T, MX-100... Call

NEC

3550 Spinwriter, 30 CPS, 203 Col., letter quality, (Parallel)... $1,850
Tractor for NEC 3550 .... $245
8023A, 100 CPS, 80 col., par.. $385

C. ITOH

8510AP Prowriter, 120 CPS, 80 col., graphics,(Parallel) ...... $Call
1550 Prowriter-II, 120 CPS, 136 col., 2K buffer, graphics,(parallel) $Call

RITEMAN

120 CPS, 9x9 matrix, tractor/friction feed, compact. (parallel) $389

TOSHIBA P1350

Super dot-matrix printer w/24-pin hi-resolution head. 192 CPS draft, 100 CPS letter-quality (parallel) $call

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ML-82A, 120 CPS, 80 col, pin & friction feed, serial & parallel .$379
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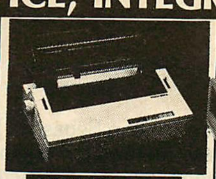
ML-92P, 160 CPS, 80 col., friction & tractor feed, (parallel) $499
ML-93P, 160 CPS, 136 col., tractor & friction feed, (parallel). . . $849

IDS PRISM

IDS Prism 80C, 200 CPS, 80 col., 4-color, graphics, friction/tractor feed, sheet feeder, (parallel) ... $1,259
IDS Prism 132C, above but 132 col. Parallel $1,495



BROTHER HR-25

New! 23 CPS daisywheel printer w/ 2 color printing, 3K buffer, proportional spacing, etc. Parallel. $769

SILVER REED EXP-550

16 CPS daisywheel printer, bi-directional printing, proportional and incremental spacing. Parallel . $649

C. ITOH F-10

40 CPS daisywheel (parallel) $1,089
55 CPS daisywheel (parallel) $1,349

DYNAX DX-15

13 CPS daisywheel printer, 2-color printing, 3K buffer, (parallel) .$Call

JUKI 6100

18 CPS daisywheel, 13" platen, 2K buffer, 3-pitch, (parallel).... $539

FUJITSU SP-830

A super daisywheel printer w/ultra fast 80 CPS printing speed, plus many outstanding features $2,095

DAISYWRITER 2000

The intelligent letter-quality printer w/48K built-in buffer memory, 17 CPS, bi-directional, auto margin justification, universal interfaces $1,059

TELETEX TTX-1040

TTX-1014, 12 CPS daisywheel with built-in tractor adjustable 2¼-14½". Parallel & serial interfaces .. $519

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Built-in text edit & graphic capability. Design for upgrading to stand-alone computer, word processing & telecom system. 80x25 line swivel screen, 10 function keys & numeric keypad. . $549
Complete w/1014 printer.... $999

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This is the famous daisywheel printer that sets the industry standard for reliability & durability. 16 CPS, bi-directional & proportional spacing. 10,12,15 pitch. Uses standard typewriter ribbon. 16½" paper. Parallel interface. We have purchased a huge quantity of this printer and offering to you at an unbelievable price ... **$599**

AST Multi-Function Cards for IBM PC and XT *New Low Prices!*

(Each card now comes w/ SuperDrive & SuperSpool)

ComboPlus II Cards

Amount of memory installed on board	none	64K	128K	192K	256K
with serial, parallel & clock/calendar	$225	$265	$315	$365	$415

SixPakPlus Cards

Six-function card with 64K-384K RAM memory, Parallel port, Serial port, Optional Game port, Clock-Calendar, SuperDrive & SuperSpool Software.

Memory installed on card	none	64K	128K	192K	256K	320K	384K
with parallel, serial ports & clock	$227	$267	$317	$367	$417	$467	$517
above plus game port	$262	$302	$352	$402	$452	$502	$552

MegaPlus II Cards

Amount of memory installed on board	None	64K	128K	192K	256K
w/serial port No. 1 & clock	$226	$266	$316	$366	$416
w/either parallel or serial port No. 2	$274	$314	$364	$414	$464
w/both parallel & serial port No. 2	$309	$349	$399	$449	$499

MegaPak — expands a fully populated MegaPlus card(256K) to 512K $299

I/O Plus II Cards

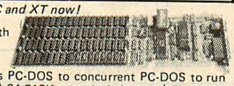
Standard card w/one serial port (S1) and clock/calendar. $129
Additional Parallel (P), Game (G), or Serial 2 (S2) port .... add $35 ea.

QUADRAM QUADBOARD - Multi-Function board for IBM-PC. Full parity checking & memory selective addressing. w/QSpool & QDrive software.

Amount of memory installed on card	none	64K	128K	192K	256K
with parallel, serial ports, clock/calendar	$235	$275	$325	$375	$425

Add Multi-Tasking to your IBM-PC and XT now!

TASC MASTER software with AddRam Elite or AddRam Plus *Ultimate* Multi-Function Boards



★TASCMASTER software converts PC-DOS to concurrent PC-DOS to run up to 9 programs simutaneously. ★64-512K on a single board. ★Real time clock/calendar w/NiCad battery that recharges itself. ★RamSpool is hard disk supported under DOS 2.0 ★RamDisk creates up to 2 electronic disks.

AddRam Elite (parallel & serial ports) AddRam Plus (Two serial ports)

Memory installed	64K	128K	192K	256K	320K	384K	448K	512K
	$399	$459	$519	$579	$639	$699	$759	$819

★★★★ RGB COLOR ★★★★

BMC BM-AU9191MU, 13" RGB color, 640-dot, 16 color ... $449
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Amdek RGB Color II Plus, 640-dot, 16 colors $459
Quadchrome, 12" RGB Color, 690-dot. $569
Zenith ZVM 134 RGB Color .$399

★★★ GREEN SCREEN ★★★

Dynax GM-120, 12" green, 600 line. 20 MHz. List $200...... $129
USI PI-2, 12" green, 1,000 line, 20 MHz. $155
Taxan KG-12N, 12" green 800-dot, List $199.00........ $149

★★★ AMBER SCREEN ★★★

Amdek 310A, 12" amber, 720-dot, runs on IBM monochrome card & multi-display cards only .$179
Dynax AM121, 12" umber, 600-dot 20 MHz. List $250 ..... $149
Taxan KA12N, 12" amber, 800-dot, List $205.00........ $150
USI PI-3, 12" amber, 1,000-dot, 20 Mhz. $169

5¼ DISK DRIVES

Tandon TM-100-1 SSDD 160K .$159
Tandon TM-100-2, DSDD 320K $225
Tandon Half-Height, DSDD 320K $219
TEAC 55B Half ht. DSDD 320K $279
Control Data full ht. DSDD 320K $259
QUME half height DSDD 320K $249
Panasonic half ht. DSDD 320K $199

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Friday		$199
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TK!Solver	$299	$219
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PFS: Report		$85
Versaform	$389	$249
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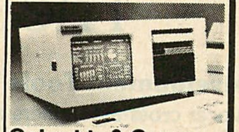
Peach Text 5000		$237
The Tax Manager	$250	$179
VisiCalc/256K	$250	$169
Real Estate Analyzer	$250	$189
SuperCalc I	$295	$125
SuperCalc II	$295	$179
Spell Guard	$195	$119
Super Writer	$295	$185



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300 ------ $209
1200------ $485
1200B--- $429

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CIRCLE NO. 144 ON READER SERVICE CARD

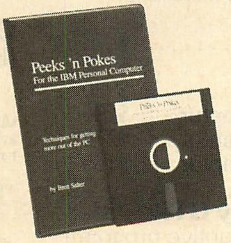
Know Thy PC!

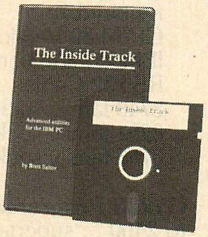
Are you writing programs in BASIC or Pascal? The popular **Peeks 'n Pokes** has a disk with 58 programs and a 38-page manual that helps you get 'underneath the covers' of the PC. Learn how to use PEEK, POKE, INP, OUT, and DOS/BIOS function calls to do what you want, fast! Do you want to perform functions not available from BASIC or Pascal? It's all explained in the manual and demonstrated in the sample programs. Source code included!

Want to know more? **The Inside Track!** is a collection of advanced utilities for the PC programmer. It contains a disk with 61 programs, a 42-page manual, and a fold-out memory map that helps you get better performance from the PC. With this package you can give your programs assembler-assisted speed from high-level languages, get control over memory, customize and control the PC, and more. Some programs require DOS 2.00. Source code included!

Peeks 'n Pokes shows you how to:

- Access the system's configuration
- Unprotect BASIC programs
- Scroll part or all of the screen
- Access the file directory
- Logically swap printers
- Read and change the keyboard
- Find more Peeks and Pokes
- And much more... for only $30.00





The Inside Track! shows you how to:

- Read/write files as fast as DOS
- Display data on the screen faster
- Reserve memory for your use
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- Copy-protect your programs
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- And much more... for only $45.00

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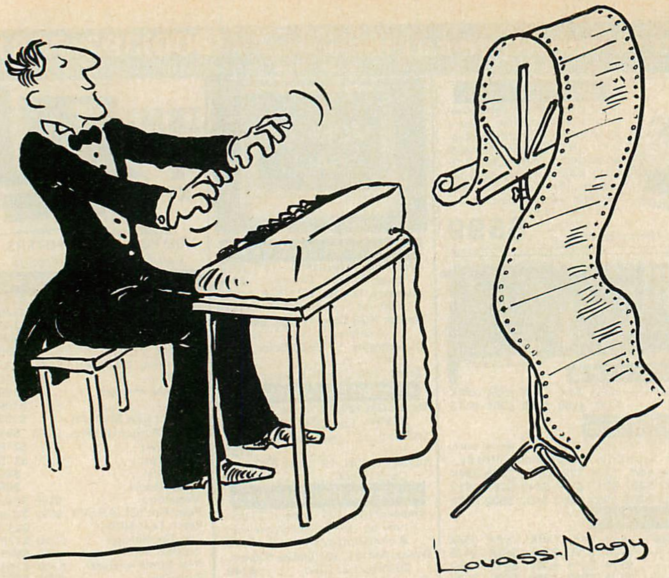

Before Johann Sebastian Bach developed a new method of tuning, you had to change instruments practically every time you wanted to change keys. Very difficult.

Before Avocet introduced its family of cross-assemblers, developing micro-processor software was much the same. You needed a separate development system for practically every type of processor. Very difficult and very expensive.

But with Avocet's cross-assemblers, a single computer can develop software for virtually any microprocessor! Does that put us in a league with Bach? You decide.

The Well-Tempered Cross-Assembler

Development Tools That Work

Avocet cross-assemblers are fast, reliable and user-proven in over 3 years of actual use. Ask NASA, IBM, XEROX or the hundreds of other organizations that use them. Every time you see a new microprocessor-based product, there's a good chance it was developed with Avocet cross-assemblers.

Avocet cross-assemblers are easy to use. They run on any computer with CP/M* and process assembly language for the most popular microprocessor families.

5¼" disk formats available at no extra cost include Osborne, Xerox, H-P, IBM PC, Kaypro, North Star, Zenith, Televideo, Otrona, DEC.

Turn Your Computer Into A Complete Development System

Of course, there's more. Avocet has the tools you need from start to finish to enter, assemble and test your software and finally cast it in EPROM:

Text Editor VEDIT -- full-screen text editor by CompuView. Makes source code entry a snap. Full-screen text editing, plus TECO-like macro facility for repetitive tasks. Pre-configured for over 40 terminals and personal computers as well as in user-configurable form.

CP/M-80 version $150
CP/M-86 or MDOS version $195
(when ordered with any Avocet product)

EPROM Programmer -- Model 7128 EPROM Programmer by GTek programs most EPROMS without the need for personality modules. Self-contained power supply ... accepts ASCII commands and data from any computer through RS 232 serial interface. Cross-assembler hex object files can be down-loaded directly. Commands include verify and read, as well as partial programming.

PROM types supported: 2508, 2758, 2516, 2716, 2532, 2732, 2732A, 27C32, MCM8766, 2564, 2764, 27C64, 27128, 8748, 8741, 8749, 8742, 8751, 8755, plus Seeq and Xicor EEPROMS.

<table>
<tr><th>Avocet Cross-assembler</th><th>Target Microprocessor</th><th>CP/M-80 Version</th><th>CP/M-86 IBM PC, MSDOS** Versions</th></tr>
<tr><td>XASMZ80</td><td>Z-80</td><td rowspan="2"></td><td rowspan="10">$250.00 each</td></tr>
<tr><td>XASM85</td><td>8085</td></tr>
<tr><td>XASM05</td><td>6805</td><td rowspan="10">$200.00 each</td></tr>
<tr><td>XASM09</td><td>6809</td></tr>
<tr><td>XASM18</td><td>1802</td></tr>
<tr><td>XASM48</td><td>8048/8041</td></tr>
<tr><td>XASM51</td><td>8051</td></tr>
<tr><td>XASM65</td><td>6502</td></tr>
<tr><td>XASM68</td><td>6800/01</td></tr>
<tr><td>XASMZ8</td><td>Z8</td></tr>
<tr><td>XASMF8</td><td>F8/3870</td><td rowspan="2">$300.00 each</td></tr>
<tr><td>XASM400</td><td>COP400</td></tr>
<tr><td>XASM75</td><td>NEC 7500</td><td colspan="2">$500.00</td></tr>
<tr><td colspan="2">Coming soon: XASM68K...68000</td><td colspan="2"></td></tr>
</table>

(Upgrade kits will be available for new PROM types as they are introduced.)

Programmer $429
Options include:
Software Driver Package -- enhanced features, no installation required.
CP/M-80 Version ....$ 75
IBM PC Version .... $ 95
RS 232 Cable ....$ 30
8748 family socket adaptor . . . $ 98
8751 family socket adaptor . . . $174
8755 family socket adaptor . . . $135

G7228 Programmer by GTek -- baud to 2400 ... superfast, adaptive programming algorithms ... programs 2764 in one minute.

Programmer $549

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Converter, each version $250

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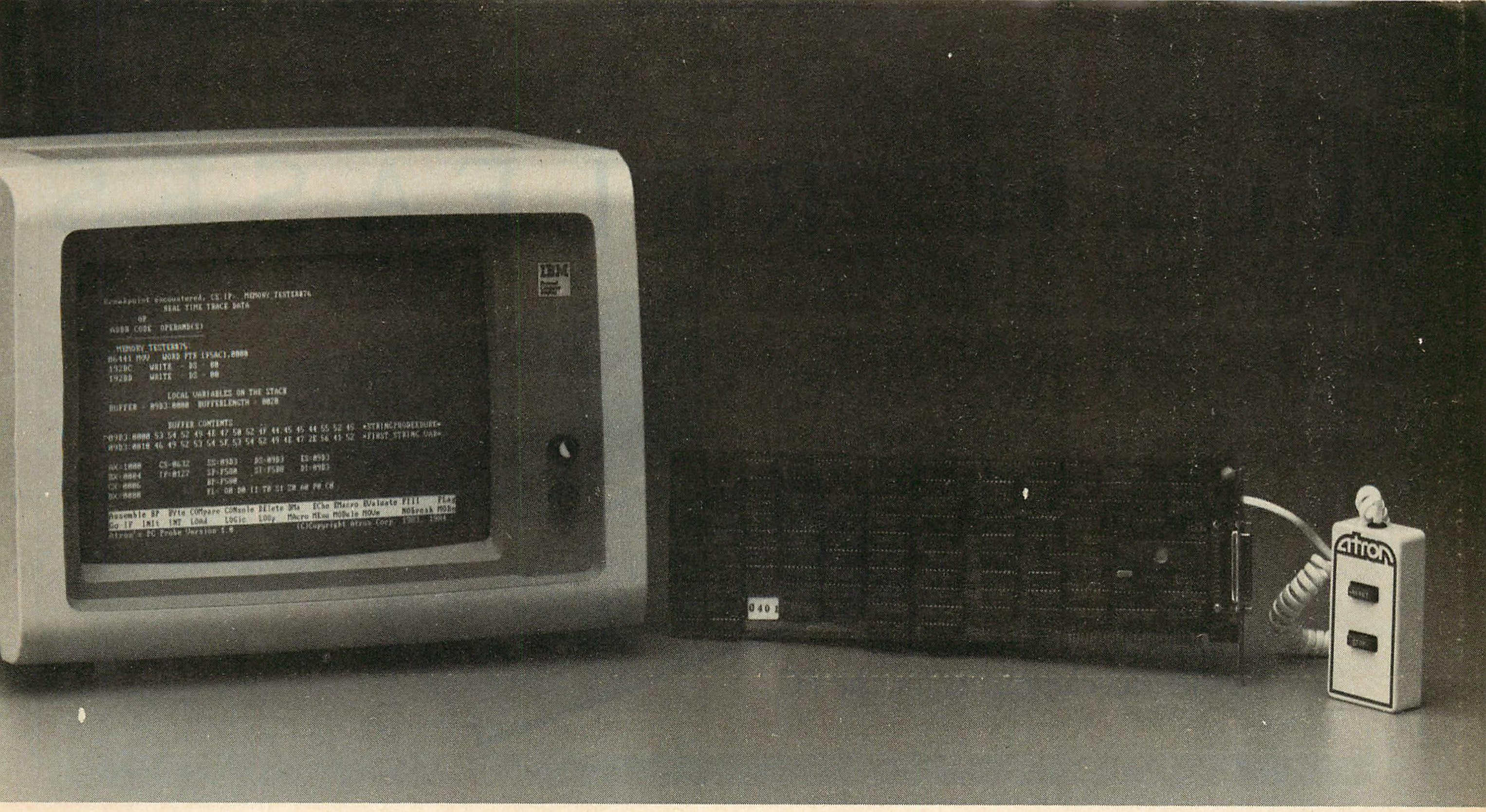

ATRON Announces A State of the Art Advance in Software Debugging—PC Probe

PROGRAMMERS AND MANAGERS know that finding bugs during new product development and over the entire product life cycle adds up to a significant portion of total product development cost and support time. Investing in the right debugging tools will greatly improve time to market as well as minimize development cost. Atron Corp. has the right debugging tools for the PC environment. These are:

1) PC PROBE
2) SOFTWARE PROBE
3) PERFORMANCE ANALYZER

PC PROBE plugs into a PC or compatible. It is a total system debugger with features like:

Real Time Trace
Program flow is saved in trace memory while running at full speed. PC PROBE can display trace data as high level language line numbers, procedure names etc. — or as 8088 instructions. In addition, DMA cycles, interrupt lines and external logic probes can be traced. Real time trace answers the question "How did I get here"?

Memory Protection
What good is a debugger that can be wiped out by an undebugged program? *PROBE* software is write protected and can't be changed.

Hardware Breakpoints
The PC PROBE has 8 breakpoints and can trap conditions such as instruction execution, read, write, IO, DMA, interrupt, or external logic probes. Breakpoints can also be set on ranges of address or data — symbolically too!

Enhanced Human Interface
The PC PROBE designers know the importance of EASE OF USE. The PC PROBE interface has a menu window which displays the syntax of each command — so you never have to remember how a command works. It also recalls the previous invocation of each command to save tedious typing — and tedious thinking!

Symbolic Debugging
Avoid the tedium of sifting through link maps to find out where things are. The PC PROBE uses your program symbols.

Macro Commands
Why be limited by a fixed set of debugging commands? PC PROBE lets you create your own powerful macro commands with parameter passing, nesting, LOOPING and IF/THEN/ELSE control.

ANNOUNCING SOFTWARE PROBE

The same great software used on PC PROBE is now available separately as SOFTWARE PROBE —

ONLY $295

Software probe is the only software debugger available which provides a hardware reset and break box for program crash recovery. What good is a software debugger if you can't get control of run away programs?

PERFORMANCE ANALYZER
How do you find time critical program problems or know where to start performance tuning your software? Get Atron's new Software Performance and Timing Analyzer. Then you can display historgrams of how your programs run — by time or by events. You can perform many different timing measurements.

Atron has many happy customers who have made critical product schedules because of PC PROBE. Why waste time on primitive debugging techniques? — Call us today and ask for your 12-page data sheet. Manuals also available for $25.

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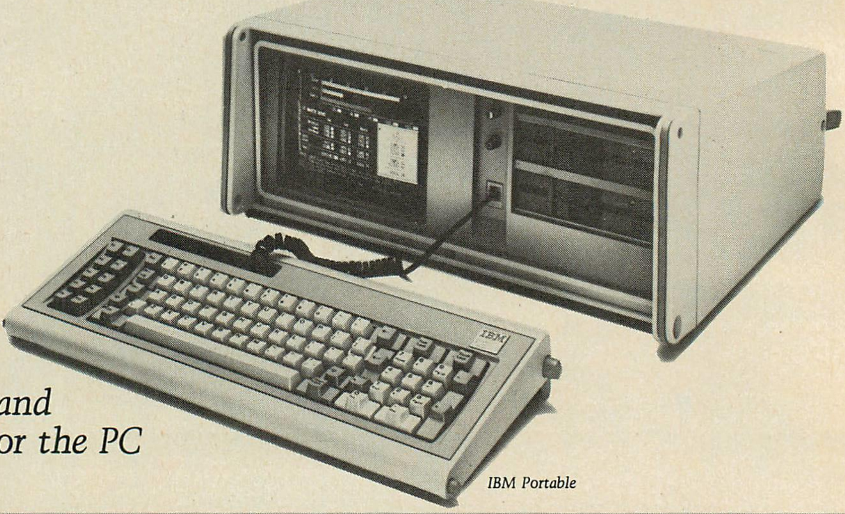
TECH RELEASES


IBM Portable

Hardware, software, and other developments for the PC

HARDWARE

IBM has announced the **IBM Portable Personal Computer,** a lighter, smaller model of the IBM PC. The computer weighs approximately 30 pounds and measures 20 x 17 x 8 inches. It features 256k RAM, expandable to 512k; a built-in, 9-inch amber monitor that displays graphics and up to 25 lines with 80 characters per line; a universal power supply for use in different countries with the addition of an appropriate power cord; one 360k slimline diskette drive and adapter; a color/graphics monitor adapter; five additional expansion slots in the system unit; and a 12-month warranty. An optional second disk drive can be added to the system. The IBM Portable Personal Computer uses the same 16-bit microprocessor used in the IBM PC, PC XT, and PC*jr* and, using PC-DOS 2.1, can run most of the software already available for those machines. It can also use most existing IBM PC hardware options. $2795.

IBM
Entry Systems Division
P.O. Box 2989
Delray Beach, FL 33444
305-241-7614

CIRCLE 460 ON READER SERVICE CARD

Another new product from **IBM** is the **IBM 9002 desktop computer,** which can internally process 32 bits of information at a time. An optional XENIX operating system, offered by IBM Instruments, Inc., permits up to four individuals to use the system simultaneously and allows users to take advantage of many commercially available UNIX and XENIX application programs. A small business or department can use the 9002 as a powerful desktop computer for one professional or, with XENIX, as a host supporting an additional three users through attached terminals. Up to four 10-megabyte hard disk drives, four 5¼- or 8-inch diskette drives, and a system printer can also be attached. The desktop unit retains the high-resolution, quality graphics monochrome display of the IBM System 9000 family. Its detached keyboard unit combines a full-function keypad with a standard 83-key keyboard. $6495 for the system unit, display, keyboard, and standard operating system. The one-time XENIX operating system license charge is $995. A complete IBM System 9000 with XENIX starts at $15,960, including the required 10-megabyte hard disk, diskette, additional memory, and memory management card installed.

IBM
Information Systems Group
900 King Street
Rye Brook, NY 10573
914-934-4834

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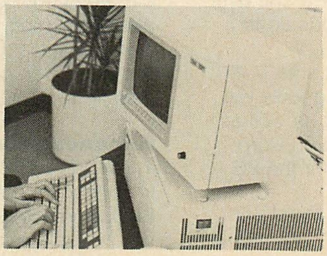


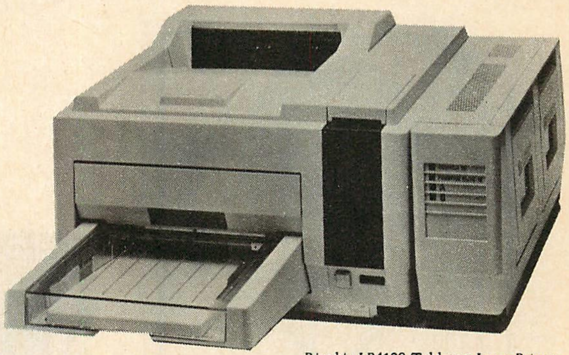
Also from **IBM** comes the **IBM Personal Computer Cluster Program,** software to connect in a cluster up to 64 IBM PCs, PC XTs, Portable PCs, or entry model PCjrs. A Cluster Program license is required for each system. With the program, users can exchange and share messages and information between workstations connected by cable. Workstations can also share information and storage space on a fixed disk drive at one machine in the cluster. To connect an IBM PC, PC XT, or Portable PC to a cluster, the IBM Personal Computer Cluster Adapter is required; for a PCjr, the IBM PCjr Cluster Attachment is needed. $2540 for a cluster of one PC XT and four PCs, including all licenses, adapters, and cable kits.

IBM
Entry Systems Division
P.O. Box 2989
Delray Beach, FL 33444
305-241-7614

CIRCLE 462 ON READER SERVICE CARD

IBM also announced that, with new **graphics adapter cards,** the IBM 3270 PC can now be used to create pie charts, bar charts, and other business graphics from a program at a host computer or one loaded into the workstation from a diskette. The 3270 PC, which can display up to seven windows of information simultaneously, can be used to create both host and PC business graphics. With the windowing capability of this workstation, a person can now display a PC graphics application, an image of a document, text, and data in four separate windows at the same time. IBM also introduced an **image-viewing program** that can be used

Control Data's StorageMaster



Ricoh's LP4120 Tabletop Laser Printer

with the 3270 PC to view image documents, as well as to process alphanumeric characters, data, or business graphics. $800 for host graphics card; $550 for PC graphics card. One-time charge for the image-view facility program is $5,400.

IBM
Information Systems Group
900 King Street
Rye Brook, NY 10573
914-934-4836

CIRCLE 464 ON READER SERVICE CARD

The **Cygnus add-on board** from **Titan Technologies, Inc.** provides a real-time clock/calendar, a game controller interface, and a choice of serial or parallel printer ports on one card, which can fit into any PC slot, including the "short slots" of the XT. Cygnus is available in two versions: the Cygnus-S1, which provides an asynchronous serial communications port; and the Cygnus-P1, which features a parallel printer port with a unique bidirectional capability. $199 for Cygnus-P1; $299 for Cygnus-S1.

TITAN TECHNOLOGIES
310 West Ann Street
Ann Arbor, MI 48104
313-662-8542

CIRCLE 463 ON READER SERVICE CARD

Two 5.25-inch Winchester disk subsystems with 18 or 30 megabytes of storage capacity have been announced by **Control Data Corporation.** The new **StorageMaster 409, 518, and 530** subsystems are for use with personal computers employing the IBM architecture. Each subsystem includes a cabinet that houses a disk drive, power supply, and a fan. Also supplied is a single-board controller for installation in the IBM PC processor unit. The StorageMaster subsystems will be available at Sears Business Systems Centers and participating ComputerLand stores. $2595 for model 518; $3390 for model 530.

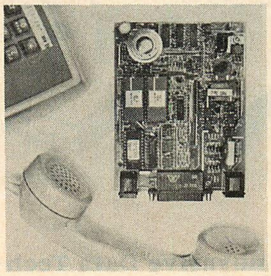
CONTROL DATA CORPORATION
8100 34th Ave. S
Minneapolis, MN 55440
612-853-8100

CIRCLE 465 ON READER SERVICE CARD

The **POPCOM Model X100** from **Prentice Corporation** is a personal communications modem product capable of true voice and data switching at the user's workstation, which eliminates the need for separate telephone lines for the telephone and personal computer. The Model X100 is fully compatible with 103, 113, and 212A dial-up modems and connects to all standard single-and multi-line phone equipment. $475.

PRENTICE CORPORATION
266 Caspian Drive
P.O. Box 3544
Sunnyvale, CA 94088
408-734-9810

CIRCLE 466 ON READER SERVICE CARD



Real Time Devices has announced the **Prototype Development Board** (PD100), which provides the means to quickly interface prototype circuitry. A unique feature of the PD100 is a switch-selectable address decoder that frees the experimenter to concentrate on his design. Four I/O device select input and output signals, four power supply voltages, and a buffered data bus are available at wire wrap posts. A rocker switch allows the selection of up to four unique addresses that do not contend with present IBM peripherals. This permits up to four boards to be utilized in one PC system. $99 for board and manual. $20 for manual alone.

REAL TIME DEVICES
P.O. Box 906
State College, PA 16801
814-234-8087

CIRCLE 467 ON READER SERVICE CARD

The **LP 4120,** a tabletop laser printer capable of printing 12 pages per minute, has been announced by **Ricoh of America Inc.** At 112 pounds, the LP 4120 is one of the smallest laser printers available. It employs the Ricoh LP Controller 120, which has two 128-character internal fonts. Two other fonts can also be used. $9,950.

RICOH OF AMERICA
20 Gloria Lane
Fairfield, NJ 07006
201-575-9550

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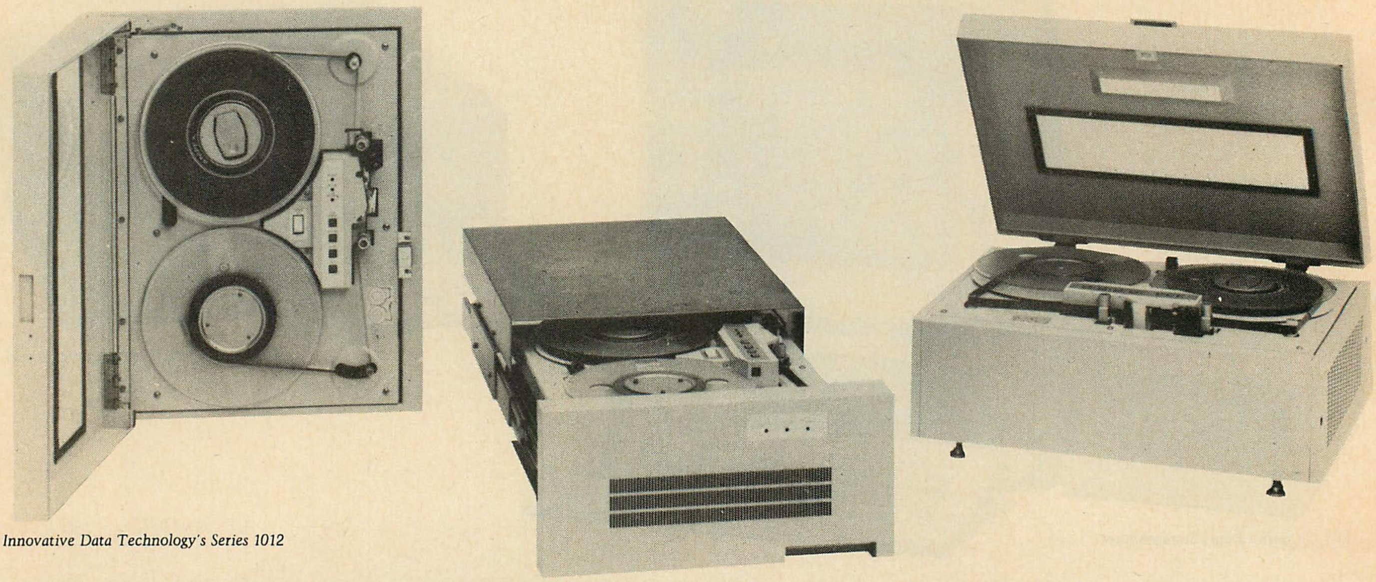


Innovative Data Technology's Series 1012

Nestar Systems Inc.'s PLAN 2000 allows users to network IBM PCs, XTs, and compatibles to achieve the benefits of shared data bases, hard disks, and printers at a low cost. In PLAN 2000, the PC that acts as a file server is not dedicated to network functions, so the user can run applications at the same time that network functions are processed. Up to 255 stations can be connected to the same network, with a maximum distance of 22,000 feet between any two PCs. The network uses the ARCnet token-passing protocol, which has a data rate of 2.5 megabits per second. $1995.

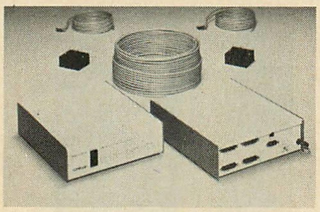
NESTAR SYSTEMS INC.
2585 East Bayshore Road
Palo Alto, CA 94303
415-493-2223

CIRCLE 469 ON READER SERVICE CARD

The **XLAN Kit** from **Complexx Systems** provides everything needed to create a sophisticated local area network for up to six devices. The network created by the XLAN kit is a baseband, CSMA LAN that operates at transmission rate of one megabit per second. Included in the kit are two StationMate communication devices, 100 feet of twisted/shielded wire, and all of the connection hardware necessary to build the network. Each StationMate has three RS-232C ports for connecting computers and peripherals and integral modem with auto dial/answer. $2995.

COMPLEXX SYSTEMS
4930 Research Drive
Huntsville, AL 35805
205-830-4310

CIRCLE 470 ON READER SERVICE CARD



Innovative Data Technology has announced three new half-inch, nine-track, 800/1600 bpi tape subsystems for the Small Computer Systems Interface (SCSI). The **IDT Model TD1012/SCSI, IDT Model TD1050/SCSI, and IDT Model TD1750/SCSI** all use an intelligent controller embedded behind two of the tape transports or in a stand-alone 3½" chassis when used with the low-cost "streaming" recorder. Variable data block sizes are programmable in both READ and WRITE modes up to a maximum buffer size of 32K bytes. The three models differ with regard to tape transport. Model TD1012/SCSI—$4,550. Model TD1050/SCSI—$5,150. Model TD1750/SCSI—$5950.

INNOVATIVE DATA TECHNOLOGY
4060 Morena Boulevard
San Diego, CA 92117
619-270-3990

CIRCLE 471 ON READER SERVICE CARD

A new series from **Number Nine Computer Corporation, REVOLUTION Graphic Boards** for IBM PCs and compatibles, includes boards with a dual-ported design that allows the display buffer to be mapped directly to the IBM PC memory space. In addition, a single board has 256 simultaneous colors out of a 16-million-color palette. Other features include a top resolution of 1700 by 1200 pixels, color NTSC output with external RS-170 genlock circuitry and digital frame-grabbing capabilities. From $945.

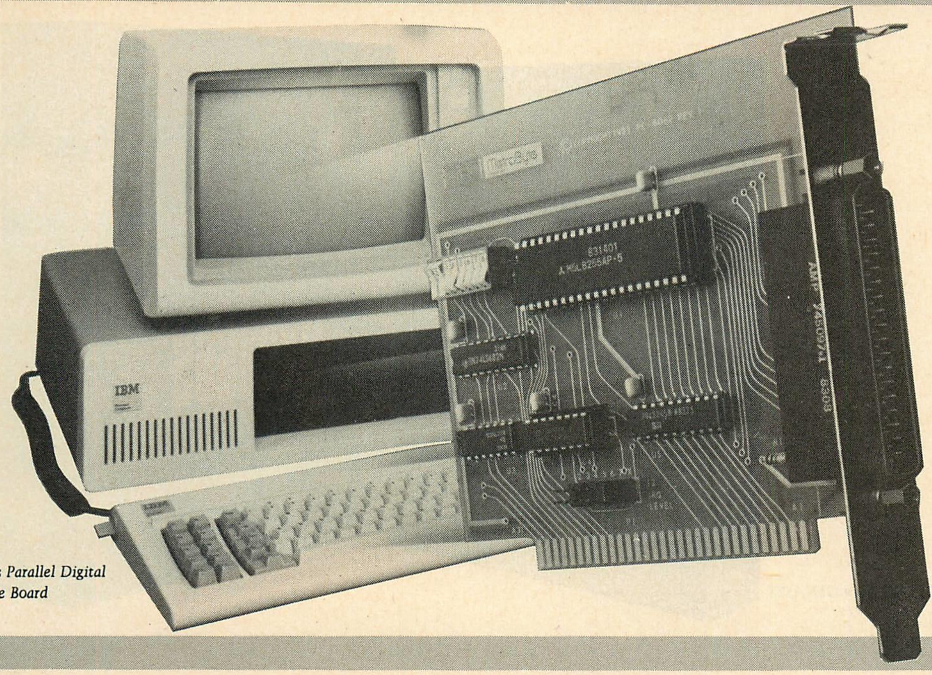
NUMBER NINE COMPUTER CORPORATION
691 Concord Avenue
Cambridge, MA 02138
617-492-0999

CIRCLE 472 ON READER SERVICE CARD

Universal Semiconductor Inc. has announced **UNICAD-1,** a software/hardware package that enables engineers to design and simulate gate array designs remotely using the IBM XT. In addition to the design software, the UNICAD package includes the Universal ISO 3/5 library of macrocells, a high-resolution printer, a graphics driver board, a mouse, a terminal emulation and communication package, and manuals. Approximately $15,000.

UNIVERSAL SEMICONDUCTOR, INC.
1925 Zanker Road
San Jose, CA 95112
408-279-2830

CIRCLE 473 ON READER SERVICE CARD



MetraByte's Parallel Digital I/O Interface Board

The **Professional Communications Management System (PCM)** from **BetaCom Corporation** is a product designed to allow insurance agents to access and distribute vital business data more rapidly, while lowering the costs of telecommunications. The PCM simply plugs into a standard RS232C port via a standard async interface adapter. No additional equipment is needed. Included in the PCM are multiple in-board modem options, an INTEL 8088 microprocessor, 64k RAM, print buffer/spooler, an RS232C CRT port, RS232C serial printer port, Centronics parallel printer port, and dual RJ11 jacks. From $1300 to $2500.

BETACOM CORPORATION
245 E. 6th Street
Suite 814
St. Paul, MN 55101
612-292-8188

CIRCLE 474 ON READER SERVICE CARD

Computer Systems has announced the **PC/8088 Component Personal Computer**, an IBM PC-compatible single-board computer that includes 64k RAM, DOS-ROM, I/O and keyboard ports with an expansion bus, and full peripheral options. The PC/8088 incorporates operational compatibility with the IBM PC and uses current IBM software, including DOS or CP/M-86. From $488.

COMPUTER SYSTEMS
26401 Harper Avenue
St. Clair Shores, MI 48081
313-779-8700

CIRCLE 475 ON READER SERVICE CARD

MetraByte's Parallel Digital I/O Interface Board, Model No. PIO-12 plugs into the IBM PC/XT, providing 24 TTL/DTL-compatible lines, enable lines, and external connections to the PC's +5-volt, +12-volt, −5-volt, and −12-volt bus power on a half-slot board via a 37-pin D connector. Three programming modes are available, permitting standard, strobed, and bidirectional I/O. $89.

METRABYTE CORPORATION
254 Tosca Drive
Stoughton, MA 02072
617-344-1990

CIRCLE 476 ON READER SERVICE CARD

SOFTWARE

Microsoft Corporation and **National Semiconductor Inc.** have announced that the **Xenix** operating system will soon be available for National Semiconductor's new NS16032 microprocessor. Xenix is Microsoft's licensed version of AT&T's UNIX operating system specifically designed for the microcomputer marketplace to provide multi-user, multi-tasking capability. Microsoft Corporation is the largest licensee of UNIX from AT&T.

MICROSOFT CORPORATION
10700 Northup Way
Bellevue, WA 98004

CIRCLE 477 ON READER SERVICE CARD

NATIONAL SEMICONDUCTOR, INC.
2900 Semiconductor Dr.
Santa Clara, CA 95051

CIRCLE 478 ON READER SERVICE CARD

Release 3.0 of the **APL*PLUS/PC System** is now available from **STSC Inc.'s** Software Publishing Division. New features include a full-screen editor for programs and data, scrolling display screens, full support for the DOS 2.0 operating system, graphics primitives for screen and printer, and an online HELP facility. The APL*PLUS/PC System is functionally compatible with STSC's other APL*PLUS systems running in the mainframe and microcomputer environments. The new system operates under PC DOS on the PC with 196K. $595.

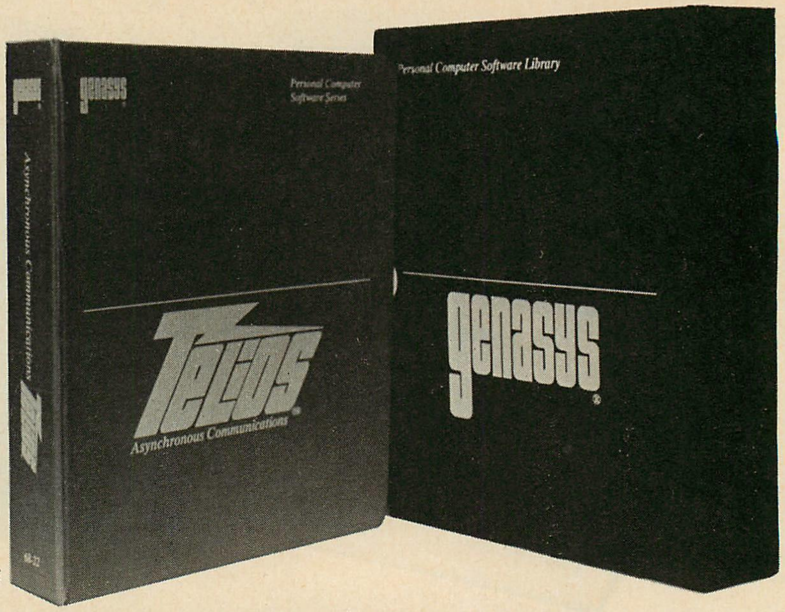
STSC, INC.
2115 East Jefferson Street
Rockville, MD 20852
301-984-5444

CIRCLE 479 ON READER SERVICE CARD

Eicon Research Limited has introduced **CACHE-NET**, a multi-user network enhancement to the DisCache Winchester Disk Subsystem. Up to 21 PCs can be linked through this network, which operates about ten times faster than the current industry leaders and about 100 times faster than various "low-cost" shared access systems. $495.

EICON RESEARCH INC
2157 Park Blvd.
Box 60456
Palo Alto, CA 94306
415-326-2164

CIRCLE 480 ON READER SERVICE CARD



TELIOS from GENASYS

GENASYS Corporation recently announced Version 2.0 of **TELIOS,** an advanced asynchronous communications package for the PC and XT. TELIOS can operate at speeds from 110 to 9600 baud through any modem (smart, acoustic, or dataphone) hardwired to a machine or via a network. It is command-driven, which makes it possible for users to establish predefined sequences of events for logging other computers, capturing data to the PC, and sending data to the host computer—with one keystroke. $119.95.

GENASYS CORPORATION
11820 Parklawn Dr.
Rockville, MD 20852
301-770-4600

CIRCLE 481 ON READER SERVICE CARD

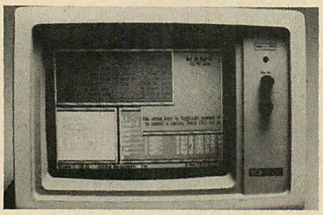
Lantech Systems, Inc. has announced **uNETix®**, a UNIX®-based multi-tasking operating system specifically designed to network personal computers and a range of corresponding products for network control, security, programming. Compatible with UNIX and PC DOS, uNETix is an operating system that runs on many 8086/8088-based microcomputers, including the IBM PC. The core of uNETix is a stand-alone system that brings multi-tasking capabilities to the single computer user. Lantech also offers two networking versions of the operating system.

With any version of uNETix, a user can display up to 10 active windows on the screen, processing a different task in each window simultaneously. All versions come with optional terminal emulator utility, permitting a user to log in to a remote mini or mainframe system.

Expanding on stand-alone uNETix, uNETix-DFS® is distributed file system that lets users access files on other microcomputers in a local area network.

LANTECH SYSTEMS, INC.
9635 Wendell Road
Dallas, TX 75243
214-340-4932

CIRCLE 482 ON READER SERVICE CARD



The **Practical UCSD Pascal Package** from **Network Consulting Inc.** is a kit with software needed to write UCSD Pascal programs. It combines the p-System operating system from NCI with a USCD Pascal compiler. For people who want to learn Pascal, Practical Pascal has an implementation guide that explains how to use the software plus books that explain both the p-System and the UCSD Pascal language. The package also includes the Advanced Screen Editor, Turtlegraphics, and filer. The package is $295; the Advanced Toolkit for upgrading to a full system is $300.

NETWORK CONSULTING INC.
Discovery Park, Suite 110
3700 Gilmore Way
Burnaby, BC V5G 4M1
Canada
604-430-6448

CIRCLE 483 ON READER SERVICE CARD

Coefficient Systems has announced the **VTERM II,** which combines full emulation of the DEC VT100, VT101, VT102, and VT52 terminals with many new, advanced features not yet available in any terminal. With VTERM II, users can hook a PC to any Digital Equipment Corporation mainframe and run all of the host software unchanged. VTERM II features include the transfer of files with any of four protocols, including XMODEM protocol. VTERM II also offers Coefficient Systems Corporation's VTRANS 7- and 8-bit protocols, which provide selectable CRC-16 or checksum error detection. $160.

COEFFICIENT SYSTEMS CORPORATION
611 Broadway
New York, NY 10012
212-777-6707

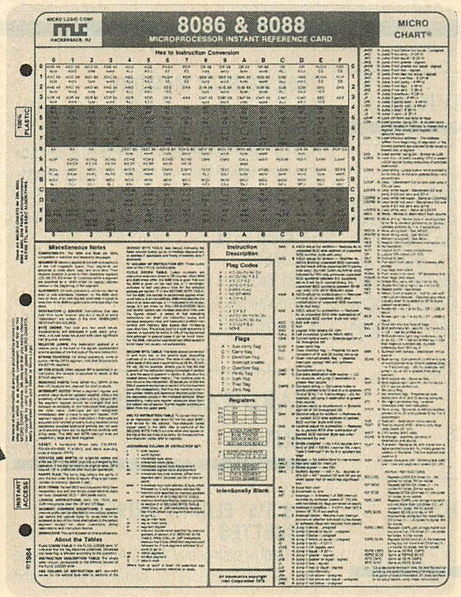
CIRCLE 484 ON READER SERVICE CARD

DATAEASE® is a relational database management system for the PC from **Software Solutions.** DATAEASE, Version 2, is a fully menu-driven program that allows users who do not know a programming language to develop applications. It is easy to learn and use, and provides the full relational capability that is required to interpret and manipulate large data bases effectively. DATAEASE is a component of SOFTEASE®, a family of integrated productivity programs by Software Solutions. $595.

SOFTWARE SOLUTIONS
305 Bic Drive
Milford, CT 06460
212-968-6668

CIRCLE 485 ON READER SERVICE CARD

Colography



Micro Chart

Cactus Software, Inc. has released Version 1.0 of **Colography®,** a full-screen color graphics editor. Capable of drawing arcs, circles, rectangles, ellipses, Colography also can rotate, flip, scale, duplicate, and move the shapes around the screen. It has a paint brush with up to 100 bristles of different colors. 128K memory is required. $99.95.

CACTUS SOFTWARE
P.O. Box 880
Peoria, AZ 85345
602-242-7953
CIRCLE 486 ON READER SERVICE CARD

A new version of **Easel®,** a graphics package that allows users to paint full-color images with a graphics tablet, is now available from **Cubicomp Corporation** to run with its CS-5 solid modeling design system for PCs and PC compatibles. The Easel package provides a range of free-stroke painting, design, and special graphics effects options that can be combined with the three-dimensional solid-model capabilities of the Cubicomp CS-5. Together, Easel and CS-5 can be used for a range of applications from architectural design to film and video animation. The CS-5 system enables the creation and manipulation of full-color, 3-D, surface-shaded models, which could previously only be performed on mainframe systems. Easel, $2,450; CS-5 graphics system, $9,700.

CUBICOMP CORPORATION
2372 Ellsworth St.
Berkeley, CA 94704
415-540-5733
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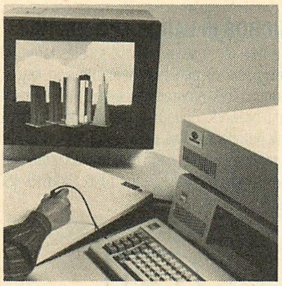

From **Whitesmiths, Ltd.** come two announcements: a new release of **Idris,** a UNIX-compatible operating system for the PC and C/370, a C Compiler for the IBM 370 architecture. The new version of Idris is designed to run as an application under the widely used MS/PC-DOS operating system, which enables users to access both Idris and MS/PC DOS application programs without rebooting the PC.

The new compiler permits C program development in the IBM mainframe environment. It also allows systems houses and DEC VAX users to move existing C and UNIX applications to the IBM 370 architecture through simple recompiling and relinking. The new compiler runs on all IBM 370, 43xx, 30xx, and plug-compatible mainframe systems under the full range of upward-compatible IBM operating systems, including MVS, VS1, SVS, MVT, and MFT. $5,000. Also available on a time-sharing program for $350 per month plus monthly systems resources through the Wang Data Center, Burlington, MA. Telephone—617-272-8550.

WHITESMITHS, LTD.
97 Lowell Road
Concord, MA 01742
617-369-8499
CIRCLE 488 ON READER SERVICE CARD

OTHER WARES

Dow Jones & Company, Inc. has purchased an equity interest in **Cdex Corporation,** a software development and marketing company that publishes tutorial software dealing with the use of PCs and of software such as VisiCalc.

DOW JONES & COMPANY, INC.
22 Cortlandt Street
New York, NY 10007
212-285-5466
CIRCLE 489 ON READER SERVICE CARD

CDEX CORPORATION
5050 El Camino Real
Suite 200
Los Altos, CA 94022
415-964-7600
CIRCLE 490 ON READER SERVICE CARD

MICRO CHART #7 from **Micro Logic Corporation** will help programmers get the information they need about the 8088 or 8086 micros more quickly. The two-sided, two-color chart is made of credit-card-type plastic and covers conversion of instructions to and from hex, instruction descriptions, cycle time, addressing modes, flag codes, register map, memory map, printouts, ASCII, cautionary notes, etc. $5.95 plus $1 postage.

MICRO LOGIC CORPORATION
P.O. Box 174
100 2nd Street
Hackensack, NJ 07602
201-342-6518
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TECH BOOK

A Special Section for Product and Service Listings

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MICROXPRESS

MICROXPRESS
305 S. State College, Suite 135
Anaheim, CA 92806
(714) 632-8512

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Send copy and remittance to PC TECH JOURNAL, TECH BOOK, 12th FLOOR, 1 PARK AVENUE, NEW YORK, NY 10016. Call (212) 725-4215 for additional information or assistance.

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(201) 731-4382

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COMPUTER INTELLIGENCE CORP.
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La Jolla, CA 92037
(619) 450-1667

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Palo Alto, CA 94301
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TWK: 910-370-7457 MUH/ALTOS

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Rosemead, CA 91770
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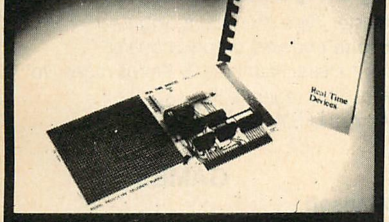

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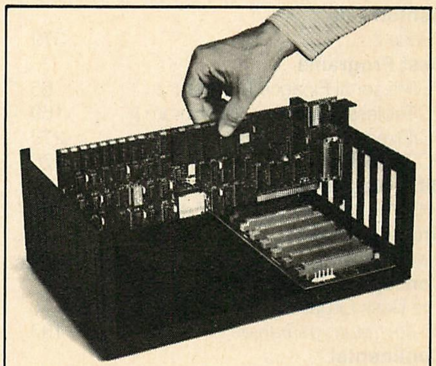

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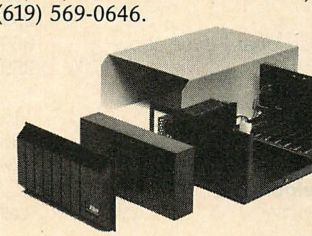

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PC CONNECTION™

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CALENDAR

MAY

May 3-6
Personal Computer Userfest. Show includes IBM, Apple, and work-alikes.
Chicago, Il
Contact: Northeast Expositions, 826 Boylston Street, Chestnut Hill, MA 02167

May 13-17
Computer Graphics 84, the National Computer Graphics Association's Fifth Annual Conference and Exposition
Anaheim, CA
Contact: Education Coordinator, National Computer Graphics Assn., 8401 Arlington Blvd., Suite 601, Fairfax, VA 22031

May 14-18
Fourth International Conference on Distributed Computing Systems
San Francisco, CA
Sponsor: IEEE Computer Society
Contact: IEEE Computer Society, 1109 Spring St., Suite 300, Silver Spring, MD 20910

May 21-23
Custom Integrated Circuits Conference
Rochester, NY
Sponsor: Electron Devices Society of IEEE and the Rochester Section of IEEE
Contact: Dr. Aris Silzars, Tektronix, Inc., P.O. Box 500 MS 59-543, Beaverton, OR 97077

May 22-25
COMDEX Spring '84
Atlanta, GA
Contact: The Interface Group, 300 First Ave., Needham, MA 02194

JUNE

June 21-23
Great Southern Computer Show
Jacksonville, FL
Contact: Great Southern Computer Shows, P.O. Box 655, Jacksonville, FL 32201, 904-356-1044

June 26-28
PCExpo
New York, NY
Contact: PCExpo, 333 Sylvan Ave., Englewood Cliffs, NJ 07632, 201-569-8542

JULY

July 9-12
National Computer Conference
Las Vegas, NV
Sponsor: AFIPS
Contact: 1815 N. Lynn St., Suite 800, Arlington, VA 22209, 703-558-3620

July 23-27
SIGGRAPH '84: Eleventh Annual Conference on Computer Graphics and Interactive Techniques
Minneapolis, MN
Sponsor: ACM-SIGGRAPH in cooperation with IEEE Technical Committee on Computer Graphics, Eurographics, the Minneapolis College of Art and Design, the University of Minnesota and the Science Museum of Minnesota.
Contact: SIGGRAPH '84 Conference Office, 11 East Wacker Drive, Chicago, IL 60601, 312-644-6610

AUGUST

August 21-24
1984 International Conference on Parallel Processing
Bellaire, MI
Sponsor: Ohio State University and IEEE
Contact: Conference on Parallel Processing, IEEE Computer Society, P.O. Box 639, Silver Spring, MD 20901

August 22-24
1984 ACM Sigmetrics Conference on Measurement and Modeling of Computer Systems
Cambridge, Massachusetts
Contact: Association for Computing Machinery, 11 West 42nd Street, New York, NY 10036

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